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ABSTRACT

Libraries should resist the temptation to relinquish to computing centers the burden of looking after the university's digital data record resources for a growing volume of intellectually important material will arrive at the university on digital data tapes. If the user must arrange for access to this material outside the library, he will be seriously disadvantaged. When a library assumes responsibility for digital data record resources, the selection of access techniques becomes the central question. The use of interactive techniques in which the user is in direct communication with the data file, combined with full-text displays is described. The model Library Program, discussed in Section III, deals with procedures that assist the user who seeks information in a mixed regime of machine access techniques and conventional library operations. The program's objective is to examine system configurations from the viewpoint of cost-benefits relationships and to study interrelationships among factors such as data-base size, content and cost, user population, equipment utilization, hardware considerations, and networking through use of electrical communications. (Other reports in this series are available as: ED 036 299, 036 301, 043 348, and 047 739). (Author/NH)

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT INTREX

SEMIANNUAL ACTIVITY REPORT

15 March 1971 - 15 September 1971

Intrex PR-12

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CAMBRIDGE MASSACHUSETTS

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PROJECT INTREX

Activity Report

I. INTRODUCTION

A reel of magnetic tape with digitally encoded data has none of the esthetic and symbolic appeal of a book. It is viewed with misgivings by the growing segment of our society which is turning away from science and technology and regards computers as dangerous, irritating and unnecessary afflictions. Nevertheless, digital data tapes are becoming important resources for the work of scholars at our universities, and libraries will have to face the question whether they should acquire, catalog, store, and make accessible these new materials. A conspicuous illustration of the impact of this question is the action of the Center for Research Libraries in sponsoring the conversion of 1970 U. S. Census tapes into a format more suitable for academic use.

The question arises at a time when the computing budgets of many universities have been expanding at a higher rate than library budgets. The sharpening competition for every dollar in a university's general funds does not strengthen the bonds of friendship between computing centers and libraries. On the contrary, this competition has given a new monetary twist to the otherwise nonsensical notion that the computing center is becoming a threat to the central role of the library in the intellectual life of the university.

In this situation, libraries will be tempted to relinquish to computing centers the burden of looking after the university's digital data record resources. It is to be hoped that they will resist this temptation, even if it involves further inroads on other services. For there can be no doubt that a growing volume of intellectually important material will arrive at the university on digital data tapes. If the user must arrange for his access to such material outside the library, he will be seriously disadvantaged. The effective use of digital data tapes will, in general, involve the concurrent use of other recorded information. Bibliographic data tapes are an outstanding example; they must be used in an environment that contains printed bibliographic resources. If the library rejects the new materials, they will ultimately be made available in a new facility in which some of the most active elements of the traditional library are duplicated. Even then, the user will not have at his command the full range of resources that he may need. The acceptance by the library of a gradually shrinking antiquarian role would surely not be in the best interests of the academic community.

Once a library has decided, as a matter of long-term policy, to assume responsibility for the digital data record resources of the university, the selection of access techniques will become a central and continuing task. Beginning with batch-processing services, the library will wish to advance to the more effective interactive techniques in which the user is in direct communication with the data file.

The use of such interactive techniques, combined with full-text displays, is described in the present report and its predecessors in this series. Experimental facilities for such use have been provided in the Barker Engineering Library at M.I.T. The Model Library Program, discussed in Section III, deals with procedures that assist the user who seeks information in a mixed regime of machine access techniques and conventional library operations. A number of distinguished librarians have visited this project during the spring and summer of 1971, and we have derived great benefit from their reactions. We hope that these exchanges will continue in the new academic year.

Carl F. J. Overhage
Cambridge, Massachusetts
15 September 1971

II. RESEARCH AND DEVELOPMENT ACTIVITIES (Electronic Systems Laboratory)

A. STATUS OF THE PROGRAM

Professor J.F. Reintjes

During the past six months, the Intrex system has been available for use on an open-environment basis at the Barker Engineering Library and the Materials Science and Engineering Center, M.I.T., and at the McKay Laboratories, Harvard University. In addition, other terminals at the M.I.T. Electronic Systems Laboratory have been used in the conduct of controlled experiments. The several hundred users of the system during this period have provided us with an excellent opportunity to observe reactions to a machine-oriented document storage and retrieval system and to measure the effectiveness of the Intrex configuration as an information-retrieval mechanism.

Several patterns are becoming evident as we gain experience with Intrex. Our principal users, undergraduate and graduate students, are enthusiastic about the on-line interactive mode of operation. Ability to negotiate for information in real time directly with the computer at interactive terminals is highly exciting to all who have come to the system. We also observe that our on-line, step-by-step instructional aids are making it possible for even novice users to begin reception of useful information within a very few minutes after they first engage the system. Users are pleased with their ability to "get going" quickly.

The availability of full text at the cathode-ray-tube terminals is being singled out for favorable comment. Having look-up and full-text-scanning capabilities at the same location is being judged highly valuable from the viewpoints of convenience, time-saving, and assurance of document usefulness.

Our experiences with the open environment during the spring academic term led us to seek ways to quantify more precisely observations on matters such as instructional aids, search strategies, and user reactions to the over-all machine environment. Interviews, questionnaires and combinations of these were evaluated during the summer months in preparation for formal use during the fall.

We are intensifying our program aimed at the design of efficient document storage and retrieval systems through use of economic analyses and modeling techniques. Our objective is to examine system configurations from the viewpoint of cost-benefits relationships and to study interrelationships among factors such as data-base size, content and cost, user population, equipment utilization, hardware considerations, and networking through use of electrical communications.

A new series of controlled experiments which seeks to establish the indicativity of various fields of catalog information has been inaugurated. Indicativity is defined as the relative usefulness of a specific field of information (title, abstract, subject-index terms, etc.) as an identifier of document value to a user, measured against his evaluation of the full text as an identifier. Certain modifications in experimental procedure have been instituted in the new series in an effort to minimize experimental error. These experiments are discussed in Section II-B.

Analysis of results obtained from controlled experiments from the viewpoint of retrieval effectiveness of the Intrex System also continued during the reporting period. Factors being examined are those influenced by the free-vocabulary, in-depth indexing method being employed by Intrex, the organization and configuration of the computer software and the format into which the raw catalog information is structured. These matters are also presented in detail in Section II-B.

Selection of new documents for our experimental data base continues at the rate of approximately 3,000 documents per year.

With respect to equipment, we have determined the modifications required to operate the M.I.T.-developed Intrex terminal in the Barker Engineering Library, a distance of eighteen-hundred feet from the buffer computer. Since information is transmitted as pulse trains of a few hundred nanoseconds duration, pulse distortion caused by coaxial-cable characteristics becomes significant and sufficient to degrade performance. Modifications required to ensure reliable transmission under remote-terminal conditions have been made and the terminal will be in operation at the at the Engineering Library in early September.

B. SYSTEM USAGE: EXPERIMENTS AND ANALYSIS

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Mr. A. R. Benenfeld
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Miss M. A. Jackson
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SUMMARY

Greatly increased use of Intrex facilities in the open environments indicated widespread acceptance of the Intrex concepts of online interactive retrieval, guaranteed access to full text, the retrieval software system and user aids. A program of controlled data collection on, and experiments with, users in the open environment has been initiated. The new series of catalog indicativity experiments has been run for nine subjects. Adviser training has been continued and improved. New instructional aids have been developed and old ones improved. Additional statistics on the inverted files have been gathered. The Class Experiment conducted during the past fall term has received further analysis in the areas of retrieval rates for Intrex, library, and informal searching, and retrieval effectiveness as influenced by type of indexing and search strategies.

INTREX FACILITIES IN OPEN ENVIRONMENTS

User Stations. Intrex now maintains three library stations in the M.I.T. and Harvard communities. The main station, located in the Barker Engineering Library at M.I.T., provides the full spectrum of system capabilities through use of a combined ARDS catalog/text-access terminal, a DATEL 30 typewriter catalog terminal and a fiche collection with facilities for reproducing hard copy (paper and/or microfiche) of full text.

A second M.I.T. station was opened this spring. This station, located in the Bush Building, brings the Intrex facilities to staff and students of our primary user community. The Bush station contains a combined ARDS terminal that permits both text and catalog access and plans are under way to move the film terminal to this station.

A third station on the Harvard campus is located in the McKay Laboratory which is the primary center for research in materials sciences at Harvard. This station, which was opened during the winter of 1971, contains an IBM 2741 typewriter terminal and provides access to the catalog system only.

Operating Experience. As the spring term progressed more and more usage was made of the two Barker terminals until there was an average of about 15 usages per day at these terminals. This amount of use is close to a saturation level at which the terminals are in almost constant use; indeed, we often experienced a queue of potential users waiting to take their turn. Since a majority of the clientele was making serious use of the system, and a sizable portion (recently over one-half) represented repeat users, this heavy usage is taken as clear evidence of the acceptance of the Intrex system by the M.I.T. community.

We postulate several reasons for the increased usage of the system at this time. The re-introduction of the advisers on a full-time basis has clearly been an important help to users and has spurred use of the system. Also, other instructional aids have been improved, as described below. Furthermore, increased publicity both from the Engineering Library and by word of mouth has increased the awareness of Intrex among the M.I.T. community. It should be noted that user word-of-mouth communications would have a positive effect on the majority of our users, who are serious users, only if the users were being well served by the system. Finally, the system itself has been improved in a number of respects: program and hardware improvements have added important capabilities as mentioned in this and previous reports; the system has become much more reliable; and the data base has been growing steadily.

During the spring academic term, the Intrex terminals at the Barker Engineering Library were operated on a regular, five-hour-a-day five-day-week schedule. During the Spring term, from February 1, 1971 thru May 31, 1971 a total of 1,005 sessions, involving a total of approximately 450 separate users, was recorded for an average of 12 sessions per working day.

Of those 1,005 sessions, slightly over half, 562, were by users who appear from the monitor records of their transactions to have been primarily interested in the material the system contains, whereas 443 were by users whose primary aim appears to have been to learn about the system. Thus, on the average, 26 sessions a week were initiated by serious users and 21 by what we might call "curious" users.

On January 25, 1971 we began to keep a directory of individual users of the system. This directory identifies each person by his status and affiliation and summarizes his use of the system. From this starting date and running through 31 May 1971, the Intrex system had 453 distinct users of whom 294 (65 percent) used the system only once, 87 (19 percent) used the system twice, 34 (8 percent) used it three times and 38 (8 percent) used it more than three times. The largest number of sessions by a repeat user was 15; these engagements were at the Harvard terminal.

Of the users during this period, 317 (70 percent) used the ARDS, whereas 218 (48 percent) used the DATEL or other typewriter consoles. The breakdown by academic levels, which showed approximately identical numbers of graduate and undergraduate students — a proportionality reflective of the M.I.T. student population, is given in the following table:

Academic Level	Number of Users
Undergraduates	124
Graduates	127
Faculty	10
Staff	8
Visitors	62
Unknown	98
Harvard (all levels)	24

By department, the largest number of users (among those whose department could be identified) came from the Electrical Engineering Department, the largest department at M.I.T. The breakdown by departments is given in the following table:

Department	No. of Identified Users
Electrical Engineering	64
Metallurgy and Materials Science	32
Mechanical Engineering	30
Physics	16
Aeronautics and Astronautics	14
Naval Architecture	14
Civil Engineering	11
Chemistry	9
Chemical Engineering	5
Mathematics	5
Nuclear Engineering	4
Earth and Planetary Science	2
Humanities	2
Management	2
Urban Studies	2
Architecture	1
Biology	1

A majority of the computer time used for these sessions (a total of 51.22 hours or 3 minutes per session) was taken up by users of the combined ARDS console (31.47 hours) and the remainder on the DATEL typewriter console (19.75 hours).

A typical ARDS user had a real-time to computer-time ratio of about 10; the corresponding figure for the DATEL was about 15, the difference being caused by the slower output rate of the typewriter.

Although a number of operating problems were encountered, in general the system was "up" more than 90 percent of the scheduled time. The primary difficulties accounting for down time were hardware problems with the text-access and the time-shared computer system, and a logistics problem of ensuring that the terminals would always be turned on at the regularly scheduled times.

During the period 1 February through 31 May, a total of 112 user requests were made for either fiche or hard (paper) copies of Intrex documents at the Microreproduction Facility in the Engineering Library. These included requests for 382 fiche copies of documents in the collection. These numbers average 6.6 users of the Facility per week, 22.4 fiche requests per week and 8.0 paper-copy requests per week. The rather striking user preference for fiche over paper is probably largely attributable to the fact that fiche copies are provided at no charge whereas paper copies cost 10 cents per page. However, some part of this preference is undoubtedly due to the extensive microfiche viewing facilities available, including the ESL arm-chair reader described in Section F.

During the summer, scheduled operations were cut back to a two-hour period (1:00 to 3:00 p.m.), five days a week for several reasons including the desire to alleviate staffing problems arising from summer vacations and the need to increase staff availability for controlled experiments, and because it was thought that the demand for system usage would decline during the summer months. Somewhat suprisingly, the demand for system use continues at a fairly high level despite the summer lull in academic activities. To accommodate demands, consoles in the Material Center are being made available for two hours (3:00 to 5:00 p.m.) by appointment.

The use of the Harvard terminal showed an initial high usage rate — 40 sessions the first 20 days — but has since stabilized to a few users a week, at most. Recent Harvard usages seem to fall into a rather homogeneous category: a few users with large numbers of relatively short usages. While we have not as yet done sufficient analysis of these Harvard usages to form conclusive judgments, it appears that this group makes frequent, casual use of the system. The reasons for the relatively low usage at Harvard compared to the Barker Library are conjectural; some possibilities would seem to be lack of a text-access facility, no advisers, typewriter-only terminal, and little publicity.

User Experience. The two primary sources of information on user opinions of the system are spontaneous user comments and solicited responses to questionnaires. Spontaneous comments are made either orally to the advisers or in writing.

The latter may be entered directly into the computer online or written in notebooks kept for this purpose.

Intrex advisers report that the comments made to them tend, on the whole, to be enthusiastic. During the spring term users entered a total of 84 written comments in the comment books placed next to the two terminals in the Engineering Library. These comments can be categorized as follows: (Several comments fit into more than one category):

* 53 (63 percent) comments are favorable toward the system, usually to a high degree

* 39 (46 percent) comments note that the system is too limited either because it does not cover enough material or is not available for a long enough time each day.

These comments can be construed as favorable to the system concept in the sense that they imply a desire to use the system.

* 29 (35 percent) comments point out deficiencies in system performance or specific system features.

* 6 (7 percent) make specific suggestions for system improvement.

We note that many of the users who made suggestions for improvements or criticized certain features also made favorable comments. Especially noteworthy is the fact that no user objected to the system concept. Collectively, these comments suggest an overwhelmingly favorable reaction to the online retrieval concept.

Those who wrote favorably of the system did so in unmistakable terms. Examples:

"I was really impressed. Found 27 potential articles."

"The Intrex system is a great contribution to the library system. I hope the entire library will some day be operated in this way."

"Remarkable system. It makes searching many times faster and n! (n factorial) times more interesting."

"I wish we had an Intrex Terminal. It is extremely helpful." (A user from Boston University)

Deficiencies, when noted, were principally in the categories of hardware problems and reliability. Thus:

"Text almost illegible"

(Comments like this one and the next are often correlated with faulty adjustment of focus or brightness of the cathode-ray tube.)

"Visual screen blurry. Too small for effective blowup of articles."

> "The system is great (when it works . .)"

> "The on/off switch for the console is in a very poor location. It is easy to bump accidentally."

> "The spacing lever gets stuck."

Comments on shortness of operating time and limited data base are summarized by these seven:

> "I have come at various times to do thesis-related work only to find the machine taken up . . . Five hours a day is too little."

> "Why is Intrex up for so little time?"

> "Please extend your system to more fields as quickly as possible (e.g., astrophysics)."

> "How about more stuff on tunneling in superconductors."

> "Hopefully, Intrex will soon include E. E. in its catalog of information. It is a very useful system and I would like to see it expanded."

> "It is frustrating to have a system like this only in an experimental stage. Hopefully, the data base will be greatly expanded within the next year (while I am still around) . . . In other words, a working system. Your experimental stage is successful."

In a two-week period (May 10 through May 21) a questionnaire, asking opinions of system features, was distributed to the users of the Intrex Consoles at the Engineering Library. A total of 45 users filled in the questionnaire including 18 undergraduates, 21 graduate students, 4 faculty or staff members, and 2 visitors. The results of this questionnaire indicate the following:

* About 86 percent of the users preferred Intrex searching to standard library searching and about 65 percent greatly preferred it.

* More than half (56 percent) were repeat users, suggesting that the novelty effect is no longer responsible for most of our usage.

* A large majority of the users (76 percent) come to the system to do a subject search.

* More than half (64 percent) found some useful documents, and of those who did not, 33 percent did not originally intend to do serious searching — they came just to try out the system.

* While the average user found the printed instructional material at least adequate, he found the personal adviser much more helpful.

Experimental Program. A series of programs to make more effective use of the open environment at the Engineering Library for system evaluation is currently being developed. These programs are designed to focus on specific problems in system evaluation and to obtain quantitative data to develop precise system specifications.

Three such programs are currently in various stages of development. Each program is planned as a separate program for intensive application at the beginning of the Fall term; but some consideration is being given to running at least two of them in parallel since much of the data to support them are related. The three areas to be focussed on first for intensive study are:

> The evaluation of the user aids provided to help users learn about the system.
>
> The effect that the ready availability of full text has on user search strategies.
>
> The retrieval effectiveness of the system and of alternative search strategies.

A program of user experiments to evaluate the effectiveness of user aids has been developed and six users had been run through a preliminary version of this program by the end of July. User background, and experience with user aids, are determined by carefully questioning the user prior to the session. His use of the system is then carefully monitored not only by the usual procedures of computer monitoring and the advisor's observations but also by an observer who records the behavior of the user, the adviser, and the system, carefully noting those features that would be missed by the other monitoring methods.

A post-session questionnaire is then used to obtain the user's opinions of the various aids and to attempt to resolve features of his behavior that are not apparent from observations. These data are then reduced to provide quantitative measures to determine what aids, and what features of those aids are most helpful to the user.

A second program is under development to attempt to determine the utility of the immediate availability of full text and to determine its effect on user search strategies. This program will also be based on the use of pre- and post-session questionnaires and careful monitoring and post-session analysis of user behavior. We find that careful questioning of the user and thorough analysis of monitor data is required to obtain a full and correct understanding of the interactive process.

We expect that all three of these experimental programs will be producing a steady stream of increasingly reliable data during the fall term.

INTREX LIBRARIAN-TRAINING PROGRAM

A restructured program to train two additional library staff members as advisers to users on the Intrex retrieval system was offered during the spring. The restructured training program resulted from a review of the program which was run during the winter, 1971 and which was described in detail in the Semiannual Activity Report of 15 March 1971. A review of that program with its participants indicated a further need to: (1) decrease the time required to run the program; (2) place even greater emphasis on practice console sessions; (3) separate the parts of the course relating to system use, system description, and the role of the adviser more clearly than heretofore; (4) increase the emphasis on, and practice of, the role of the adviser.

The order of presentation of topics has been shifted so that the roles of the adviser are now discussed midway in the program immediately after covering the more general and elementary features of system use. At that midpoint, a practice advisory session at an active console in the open library environment was incorporated into the program. That session includes observation of a trained Intrex adviser plus a demonstration of the system to at least one user by the trainee. From this session, the trainee is expected to gain an increased sensitivity to the duties and problems of the adviser and an appreciation of the need to further understand some of the system details. Discussion of the detailed system structure, previously scattered throughout the program, has now been relegated to the latter part of the program. After the practical session, the trainee can also function as an assistant adviser when queueing problems develop in the console area.

The total program has been compressed into 18 1/2 two-hour daily sessions, whereas the program last winter had been scheduled for 25 two-hour sessions. Other beneficial features of the previous program have been retained including the participation of previously trained advisers as console instructors, and testing of the trainees at the conclusion of each unit. A new outline of the instructional units is given below.

Outline of Instructional Units for Librarian-Training Program

KEY: L - Lecture or Discussion Session C - Console Session

LC - Lecture plus Console Session (about one hour for each part)

A. Orientation (2 sessions)

(L) 1. Introduction: History and Experimental Objectives of the Intrex System; Role of the Adviser; Demonstration

(C) 2. Basic Steps in Intrex Use: Search; Catalog Output; Text Output; Typing Errors

B. System Use (6 sessions)

(LC) 3. Simple Subject Searches

(LC) 4. Combining Subject Searches: NAME, AND, OR, NOT, WITH Commands

(LC) 5. Other Primary Searches: TITLE, AUTHOR, DOCUMENT Commands; Combining Primary Search Commands

(LC) 6. Outputting: OUTPUT Command; Off-line Output; Functional Catalog Field Groups; Pseudo-Catalog Fields; Text Output; Library Microreproduction Facility

(LC) 7. Search of Uninverted Fields: RESTRICT Command and "Eyeballing"

(C) 8. Miscellaneous Intrex Commands: LONG, SHORT, TIME ON, TIME OFF, COMMENT Commands

C. Roles of the Adviser (3 sessions)

(L) 9. The Adviser's Job: Instructing, Aiding and Observing Users; Recording Information

(LC) 10. Physical, Mechanical, and Logistical Details: LOGIN, LOGOUT, INFO, LOG, BEGIN, HOLD, EXIT, QUIT Commands; Layout of Console Areas; Different Terminals and their Use; Printed Instructional Materials and Aids; Trouble Shooting

(C) 11. Practice Adviser Session: Assisting an Adviser and giving at least one demonstration

D. System Structure (7 1/2 sessions)

(LC) 12. Subject Indexing

(L) 13. Data-Base: Coverage and Document Selection; Catalog Record Structure; Catalog Fields

(2L) 14. Data Organization within the Computer: Inverted File and Catalog Record Structures; Stemming and Phrase Decomposition; CTSS; Computers, Codes, Overlays; Message Handling

(LC) 15. List Handling: USE, USE ADD, SAVE FILE, SAVE, DROP, LIST Commands

(L) 16. Text Access Facilities

(L) 17. Strategies: Roles of Thesauri, Inverted File Listings, Booleans and Synonyms; Reference Interview

(L) 18. Summary and Review Discussion

INSTRUCTIONAL AIDS

The Intrex Retrieval System offers users a broad variety of ways to learn system use. Originally, there were three such ways: A printed Reference Guide that fully describes system capabilities and their use; an online, computer-stored version of the Reference Guide that can be called for selectively by a user through the INFO command and a collection of system messages that indicate, to the user, the results of his previous request and what options are open to him at any given point in the interaction. Later, we augmented these facilities by making an Intrex adviser available to assist users.

During this reporting period six new user aids have been developed to fill gaps that users have noticed and to provide a broader spectrum of aids to meet the spectrum of user needs. These new aids are the following:

1. The User's Guide written by Professor L. S. Bryant of the M.I.T. Humanities Department, offers a more pedagogical introduction to the system than does the more encyclopedic Reference Guide. Information in this Guide is presented in a leisurely, discursive manner with many examples and hints.

2. The Summary Guide, a four-page pamphlet, provides a brief introduction for the user who prefers a document that seems less physically imposing than the Reference Guide whose apparent length has discouraged some users. This Guide is primarily intended to meet the needs of the user who is in a hurry to get started in his use of the system.

3. "Project Intrex - A Brief Description" was written by Professor C. F. J. Overhage. It provides a description of the Intrex Project with special emphasis on the Intrex retrieval system. This document describes system implementation and is thoroughly illustrated. It is intended to meet the needs of the user who is more interested in learning about the system itself than in actually obtaining information from the system's document collection.

4. "Project Intrex - Samples of Catalog Interactions" was also prepared by Professor Overhage. It consists of the teletypewriter records of two sample dialogs together with explanatory notes. This aid is intended to serve the user who finds it easier to learn from an example than by following a detailed explanation.

5. A sound-slide introduction to Intrex, described in greater detail in the Model Library Section, was developed to provide users with a simple, easily understood, overall introduction to the use of the Intrex system.

6. A capability that permits a member of the Intrex Staff to serve as an adviser from a remote location, via a second console that is slaved to the user's console, was also developed (see the Software section). This facility has been used to assist a user at Harvard, from an M.I.T. console, and appears to hold considerable promise.

A major revision of the Reference Guide has been prepared to correct known errors and to bring the Guide fully up to date. This version is in press.

Minor revisions have been made to the online dialog and the responses to the INFO command. Major revisions of this dialog and the computer-stored version of the Reference Guide are planned to update these features in line with the revised printed Reference Guide.

Improvements in the instructional aids also include more functional rearrangements of the catalog field descriptions and the subject areas covered by Intrex. These improvements are described further in Section D on Inputting.

SUBJECT/TITLE INVERTED-FILE CHARACTERISTICS

Characteristics of the inverted files are important in analyzing retrieval effectiveness and other properties of Intrex. Statistical characteristics of the Intrex subject/title inverted file have been studied by Dr. Syunsuke Uemura, a visiting researcher from the Electrotechnical Laboratory of Tokyo, Japan. The details of the study, which are given in a separate report, are summarized here. Statistics are reported primarily for the May 1971 version of the subject/title inverted file, although several earlier versions were examined in order to study changes in some characteristics as a function of file growth. The gross characteristics of that file, which covers the combined, non-common subject index and title words from 15,845 document catalog records, include 35,645 word types, 27,291 stem types, and 1,204,282 stem occurrences.

A document is assigned an average of 10 index terms (including the title as a term) with 7.6 words per term (excluding 13 common words on a stop list). Thus there are an average of 76 word tokens in the complete inverted-file-index set per document. These 76 word tokens represent an average of 39.1 unique stem types, so that each stem type occurs on the average of 76/39.1 = 1.95 times per document. The average length of a stem type is 7.8 characters.

A stem type has associated with it in its inverted-file list an average of 1.3 full (unstemmed) word types. Only 16 percent of the stem types have two or more word types but these, of course, include most of the commonly used search words. For example, of 31 search words used by students on the "irradiation embrittlement" topic in the Class Experiment (see below), 29 had stems with multiple word types in the inverted file, one had only a single type and one was not in the inverted file at all.

The average frequency of a stem type (its number of occurrences) is 44.1. Almost half (13,085 or 48 percent) of the total number of stem types occur only once. At the other end of the scale, 0.95 percent or 260 stem types, occur more than 1000 times and this group of high-frequency stems accounts for 54 percent of all stem occurrences. The most frequent stem is "magnet-" with 16,824 occurrence.

The average number of documents referenced per stem type is 22.6. This gives the same Redundancy Ratio — defined as the number of index words per document divided by the number of stem types per document, which equals, in this case, 44.1/22.6 or 1.95 — as calculated above. This ratio was 2.23 for the first 5500 documents indexed (which had a total index of 101.5 words with 45.4 stem types per document). The Redundancy Ratio was 1.75 for the latest 10,000 documents included in the file (which set had 62.7 index words and 35.8 stem types per document). An intentional change in the indexing process to reduce redundancy, which was described in the 15 September 1968 Semiannual Activity Report, brought about this decrease. It is important to consider these variations when measuring the retrieval effectiveness of Intrex as a function of depth of indexing as is done in the Section that reports on the analysis of the Class Experiment.

A ranking of the 260 high-frequency stems of several stages of inverted-file growth shows little or no change in the rank ordering. High-frequency stems were analyzed in terms of their redundancy on the basis of document references, using another redundancy ratio, defined for each stem as frequency per number of distinct documents. Synonyms were found to have similar redundancy-ratio values, whereas they do not necessarily rank closely when ordered by occurrences only. Less-technical words in this high-frequency set have a lower stem redundancy ratio than do more-technical words.

During the period 1968 to 1971 when the document collection grew by a factor of 17 (from 955 to 15,845), the number of stem types increased only by a factor of 4 (from 6,700 to 27,291). As shown in Fig. IIB-1, the number of stem types added to the inverted file during that period decreased from 6.7 to 0.85 per document. These new stem types are quite indicative of the stems with extremely low frequency

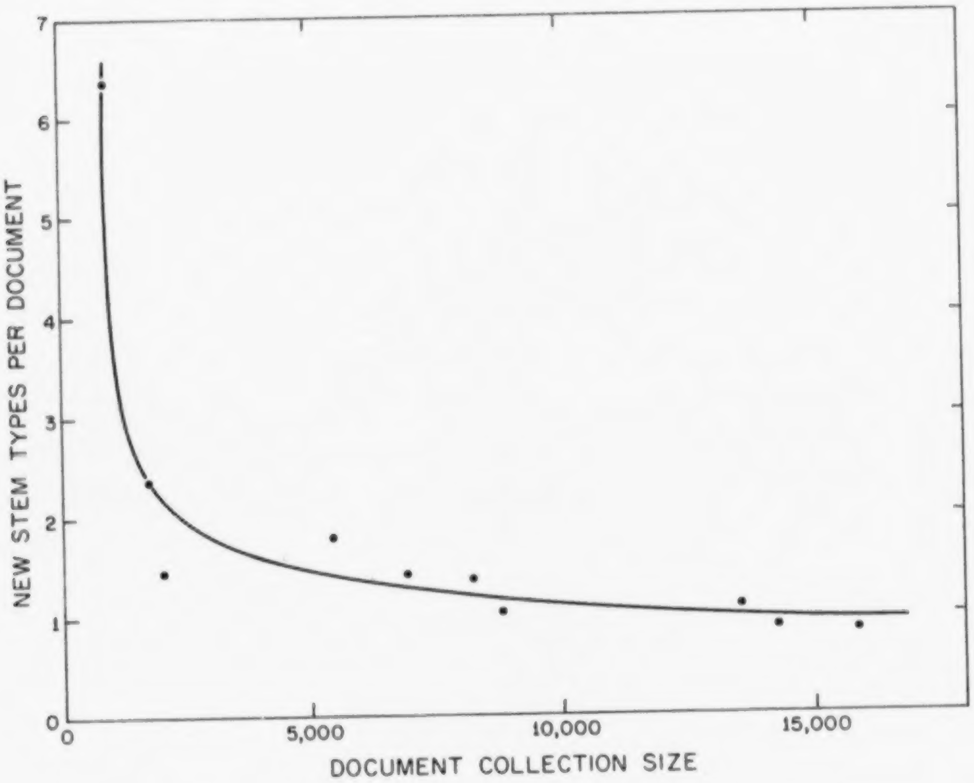

Fig. IIB-1 Number of New Stem Types per Document as a Function of Document Collection Size

and were analyzed in some detail as follows. All 309 new single-occurrence stems in a recent update batch of 482 documents with 3,254 stem types, were categorized. Some 32 percent of the new stem types were derived from technical words (21 percent were chemical formulae, 2 percent were chemical or material names, and 9 percent were other technical words), 24 percent were either symbols or numerics, 26 percent were proper nouns, 4 percent were general words, 11 percent were misspellings, and 5 percent were words that already appeared in the inverted file but were now being taken as new words because of untrimmed punctuation. Personal names accounted for more than 80 percent of the proper-noun category. It has been noted that many of the new chemical or material names and other technical words are compound words formed with prefixes.

The percentage distribution of stem occurrences by the range number assigned to the subject-index phrases in which they occur is:

Range 0:	(Generic term)	-	2.8 %
Range 1:	(Major subject)	-	14.7 %
Range 2:	(Secondary subject)	-	33.1 %
Range 3:	(Minor subject)	-	28.9 %
Range 4:	(Tool or technique)	-	11.1 %
Range 5:	(Title)	-	9.3 %

CATALOG INDICATIVITY EXPERIMENT

The catalog indicativity experiment is designed to test the effectiveness of different types of catalog information as indicators of the value of documents to users. The four types of catalog information currently being tested are title (catalog field 24), matching subject phrases (catalog field 74), abstract or excerpts (catalog fields 71, 70), and subject-index phrases (catalog field 73).

To date nine experimental subjects (ESs) have participated in the Series B part of the experiment. The revised experimental design, described in the last Activity Report, has been used for these nine ESs. Since the nine ESs constitute only a fraction of the complete sample of 20 ESs, the preliminary experimental results which are presented in this section should be viewed with a great deal of caution.

Description of Experimental Subjects. All nine ESs are affiliated with M.I.T. ES 31 is a professor of Electrical Engineering who requested information for a review article which he was writing on the magnetoelastic phenomenon. ES 29 is an undergraduate who needed information for a laboratory project in the area of materials science. The other seven ESs are graduate students. Two are in the Department of Metallurgy and Materials Science; five are in the Department of Physics. All seven sought information through Intrex that would be relevant to their doctoral theses.

Indicativity. Graphs of the indicativity of titles, matches, abstracts (or excerpts), and subjects for the nine ESs appear in Fig. IIB-2. The method of calculating indicativity is as follows: Each field rating of a document is directly compared to the full-text rating of that document.* If the difference in ratings is a whole number (0, ± 1 or ± 2), then the document is placed in the appropriate bar graph (0, ± 1, ± 2) for that field.** Borderline ratings are considered as averages of the two ratings cited. For instance, the result of comparing a '1-2' field rating (1.5) to a '1-2' full-text rating (1.5) is 0; and the result of comparing a '1-2' field rating (1.5) to a '2-3' full-text rating (2.5) is 1. If the result of comparison is a fraction (e.g., when a '1-2' is compared to a '2'), then the Cartesian method of comparison is employed.† According to

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* The possible value ratings are:

1. The article is highly useful.
2. The article is somewhat useful.
3. The article is not useful.

Borderline ratings are indicated by citing two adjacent numbers separated by a hyphen.

** The symbol '+' indicates that the field rating is higher than the full-text rating; a '-' indicates that the field rating is lower than the full-text rating.

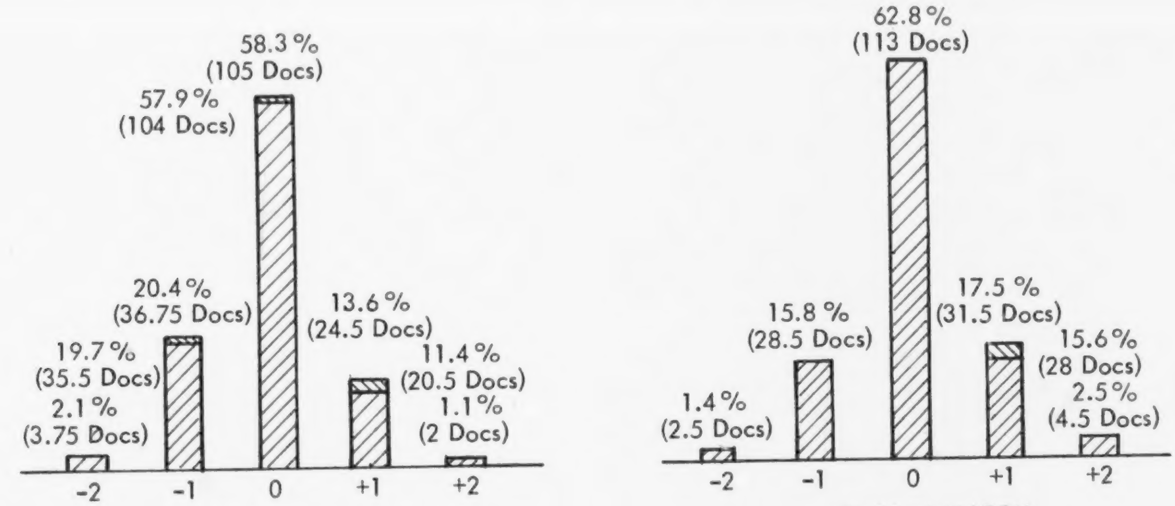
† The method is so-called because of its similarity to the method of obtaining the Cartesian product of two sets (e.g., the Cartesian product of two sets A and B is the set of all pairs (x, y) such that x is a member of A and y is a member of B).

TOTAL NUMBER DOCUMENTS EVALUATED

Field 24: 180 Documents
Field 74: 180 Documents
Field 70 or 71: 171 Documents
Field 73: 180 Documents

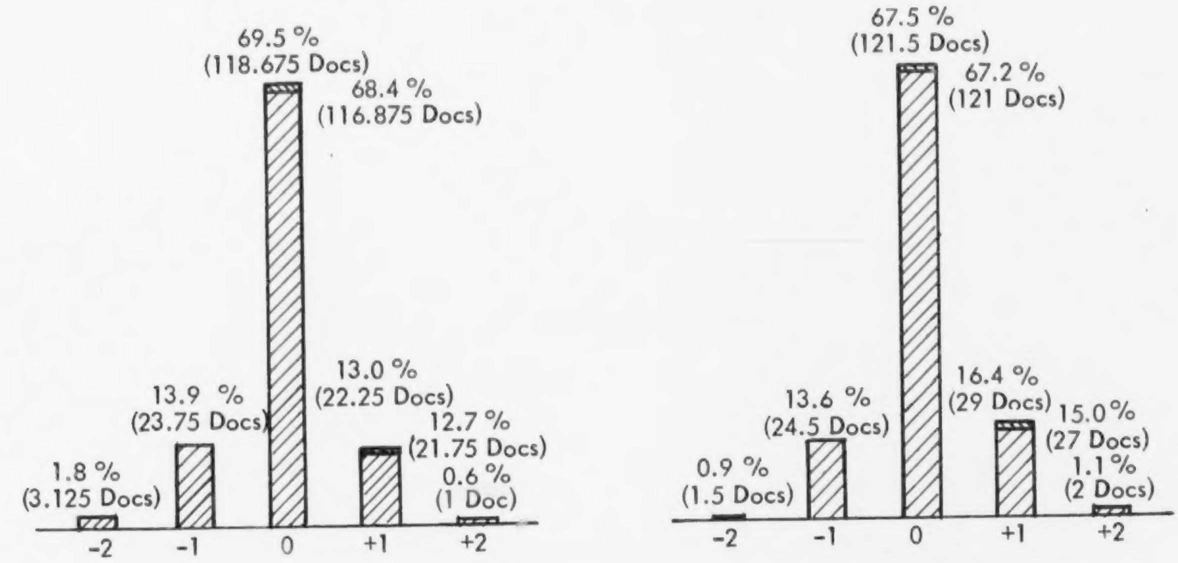
KEY:

0	Indicates catalog field and full text received same value rating
+1, +2	Indicates catalog field received higher value rating than full text
-1, -2	Indicates catalog field received lower value rating than full text
▨	Indicates that a '2' was appended to the catalog field rating or to the full text rating



Field 24 TITLE

Field 74 MATCH



Fields 70, 71 ABSTRACT or EXCERPT

Field 73 SUBJECTS

Fig. IIB-2 Indicativity of Four Fields
Nine Experimental Subjects

this method, no ratings are averaged, but instead every element of the field rating is compared to every element of the full-text rating and each comparison is considered as a certain fraction of the document ($\frac{1}{x}$ where x is the number of comparisons). For instance, if a '1-2' field rating is compared to a '2' full-text rating, half the document is graphed as +1 (the '1' of '1-2' is compared to '2') and half the document is graphed as 0 (the '2' of '1-2' is compared to '2').

When a field of a document has been presented twice for evaluation,* the two field rating are not averaged, nor are the ratings of the duplicate full texts. Instead, the Cartesian method of comparison is employed. For instance, if the two field ratings are '1' and '1-2' and the two full-text ratings are '2' and '3', the four following comparisons, each constituting one quarter of the document, are made: '1' to '2', '1-2' to '2', '1' to '3', and '1-2' to '3'. Of course the Cartesian method of comparison must be applied again to the second and fourth of the above comparisons, with each new comparison constituting one-eighth of a document. In short, the rule for graphing a document having field ratings x, y and full-text ratings m, n is to make the comparisons (x, m), (x, n), (y, m), and (y, n) and then to analyze these four comparisons in the same way that single ratings are analyzed (as described in the preceding paragraph).

Graphs of the adjusted indicativity of titles, matches, abstracts (or excerpts), and subjects are presented in Fig. IIB-3. The method of calculating adjusted indicativity is as follows: Each ES is presented the field information and full texts of approximately 10 documents having one or more field ratings which differ from the full text ratings. The ES is asked to explain, if possible, why the discrepancies in ratings occurred. On the basis of the ES's comments, an analysis of information factors is performed. Following is the code used to assign information factors to field information:

0	A variational factor relating to the judgment of the ES is responsible for the discrepancy between field rating and full-text rating.
1/2	Half the field rating is non-concurrent with the full-text rating (as with a field rating of '1-2' and a full text rating of '2') or half the full-text rating is non-concurrent with the field rating (as with a field rating of '2' and a full-text rating of '1-2') and the field information is responsible for the discrepancy (information missing or misleading); or the

---

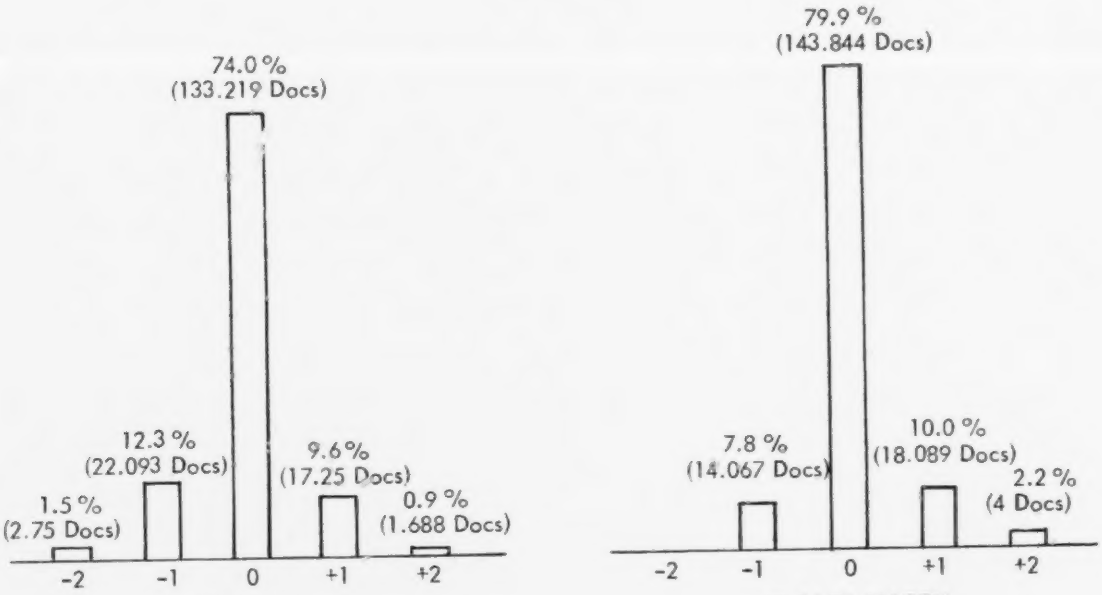
* In order to test the variability of the ESs' responses, each ES was presented with duplicates of the field information and full texts of five documents.

TOTAL NUMBER DOCUMENTS EVALUATED

Field 24: 180 Documents
Field 74: 180 Documents
Field 70 or 71: 171 Documents
Field 73: 180 Documents

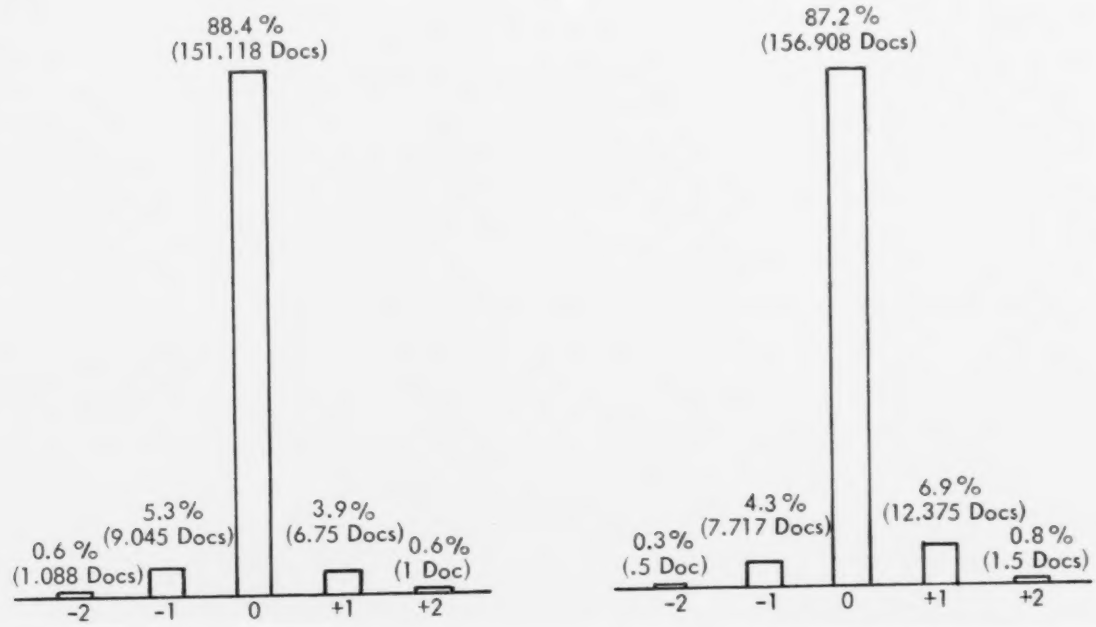
KEY:

0	Indicates catalog field and full text received same value rating
+1, +2	Indicates catalog field received higher value rating than full text
-1, -2	Indicates catalog field received lower value rating than full text



Field 24 TITLE

Field 74 MATCH



Fields 70, 71 ABSTRACT or EXCERPT

Field 73 SUBJECTS

Fig. IIB-3 Adjusted Indicativity of Four Fields
Nine Experimental Subjects

entire field rating is non-concurrent with the full-text rating, but a combination of informational and variational factors is responsible for the discrepancy.

1 The entire field rating is non-concurrent with the full-text rating and the field information is responsible for the discrepancy.

When a document with two ratings for each field and two full-text ratings is included in the analysis of information factors, one full-text rating and one discrepant rating from each field (if there is one) are presented to the ES for comment. Only one full-text rating and at most one of the two ratings from each field can be presented, yet according to the Cartesian method of comparison all four ratings must be counted in the calculation of indicativity. Hence the one field rating and one full-text rating which are presented represent only a fraction of the non-concurrence between field and full-text ratings. The fraction can range from 1 (if both field ratings are the same and both full-text ratings are the same) to 1/8 (if all four ratings are different and, for instance, the field rating is '1-2' and the full-text rating is '2'). An information factor equal to the fraction of non-concurrence is assigned if the field information is responsible for the discrepancy; an information factor which is half the fraction is assigned if a combination of informational and variational factors is responsible; an information factor of 0 is assigned if the judgment of the ES is responsible.

To calculate the number of information factors per number of non-concurrent ratings in a field, one must extrapolate from the subset of presented non-concurrent ratings to the entire set; extrapolations are done separately for each of the four non-concurrent indicativity levels (±1, ±2) in a field. The method of extrapolation assumes that the ratio of information factors to number of non-concurrent ratings in a given level is the same as the ratio of information factors to non-concurrent ratings in the sample of non-concurrent ratings from that level that were presented to the ES for comment.

Once information factors have been calculated, indicativity is adjusted by removing from the appropriate non-concurrent bar graph the difference between the number of information factors and the number of non-concurrent ratings and then moving this difference to the 0-level bar graph. The method just described has the effect of graphing as concurrent those ratings whose lack of concurrence is attributable to judgmental variation of the ES; field information is considered to be indicative of full-text value if there is strong reason to believe that the indicativity failure resulted from a judgmental variation of the ES.

Fig. IIB-2 reveals that abstracts and subject-index phrases (which are approximately equal in their ability to indicate document value) are the most indicative of the four fields. Matches (index phrases that contain words which match the words in a search request) are somewhat less indicative than abstracts and subjects; titles are least indicative. The Series A experiment, previously reported upon, yielded similar results: abstracts and subject phrases were most indicative and titles were least indicative (see 15 September 1970 Activity Report). In Series A, matches were not presented alone, as they were in Series B. Instead, they were combined with title, author, and journal location. Nevertheless the combined fields in Series A performed comparably to matches in Series B — falling between the most indicative fields (abstracts, subjects) and the least indicative field (title).[*]

After indicativity is adjusted by taking information factors into account, abstracts and subject-index phrases remain the most indicative fields; titles are still least indicative; and matching phrases are in between (see Fig. IIB-3). However, as a result of the adjustments, the 0-level bar graphs were raised by the following amounts: title, 15.7%; match, 17.1%; abstract, 18.9%; and subjects, 19.7%. The least improvement was made for titles, and the greatest for subject-index phrases. The analysis of information factors indicates that approximately half (48.7%) of the total non-concurrent ratings are attributable to inadequacies of the catalog information; the percentage varies from 62.4% for titles to 36.9% for subject phrases.

The Wilcoxon matched-pairs signed-ranks test was employed to determine whether or not there was a significant difference in indicativity between any two fields. The percent of concurrent ratings served as the measure of indicativity. The null hypothesis H_o states that the indicativity of different fields does not differ. Following are the alternative hypotheses that were accepted in favor of H_o, with the significance levels (α)[**] for a one-tailed test:

> Abstracts are more indicative than titles (raw data: $\alpha = .025$; adjusted data: $\alpha = .005$).
>
> Subject-index phrases are more indicative than titles (raw data: $\alpha = .005$; adjusted data: $\alpha = .005$).
>
> Matching phrases are more indicative than titles (adjusted data: $\alpha = .025$).
>
> Abstracts are more indicative than matching phrases (adjusted data: $\alpha = .005$).

In the post-experimental interviews ESs were asked which catalog field they found most helpful in evaluating articles. Six of the nine found abstracts most helpful;

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[*] This suggests that the addition of the three other catalog fields to the matches does not make a significant improvement over the matches alone.

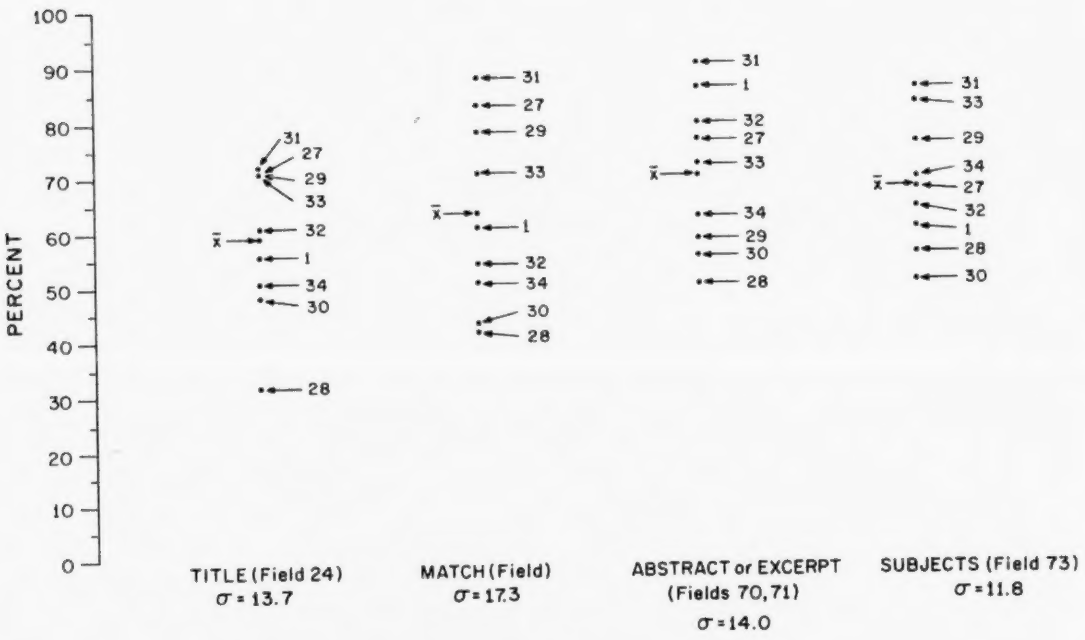
[**] The significance level is the probability that the hypothesis accepted is actually false on the basis of the statistical evidence.

one favored matches; one preferred titles; and one thought that no field was "consistently better" than any other. Abstracts were by far the favorite catalog field. It is noteworthy that even though subject-index phrases were as indicative as abstracts, not a single ES stated them to be "most helpful." In the future serious attention should be given to the issue of whether, in decisions affecting system design, primary consideration should be given to those fields which are in fact most helpful to users or to those fields which users think are most helpful. In addition, further research should investigate whether users are more likely to use those fields which are in fact helpful or those fields which they think are helpful.

Scattergrams. Figs. IIB-4 and 5 are scattergrams which display the percent of concurrent ratings in each field for each of the nine ESs, and the mean percent for each field. The values of the standard deviations are also noted. Raw data appear in Fig. IIB-4; adjusted data appear in Fig. IIB-5. A scattergram shows the spread of data around the mean; hence it gives an indication of the confidence with which we can assume that the mean of the sample coincides with the mean of the larger population. The smaller the spread of points around the mean, the more confident we can be.

The standard deviation of abstracts (raw data) is the same as the standard deviation of abstracts in the Series-A sample — 14.0. However, the standard deviations of the other fields (raw data) are less than the standard deviations of those fields in the Series-A sample: the standard deviations of titles and subjects are approximately 4% less; and the S. D. of matches is slightly less than the S. D. of the four combined fields (which include matches). These lower standard deviations indicate that we can be more confident than we could before in asserting that the means we have calculated are the true means. The standard deviations of the adjusted data are even lower than the standard deviations of the raw data. They range from only slightly less (titles) to 6% less (abstracts). Hence we can be even more confident that the means of the adjusted data are accurate. According to the raw and adjusted data, matches have the greatest spread of data around the mean. According to the raw data, subject-index phrases have the least spread whereas with the adjusted data, abstracts have the least spread.

The Length Hypothesis. The length hypothesis, as stated in previous reports, is as follows: As field length increases, indicativity increases, but indicativity per word decreases. The length hypothesis is a statement of the law of diminishing returns as it applies to catalog data. There are, however, several ways of measuring the length of a field; the two primary measures are number of word tokens and number of word types. One can also distinguish content words from noncontent words. Hence there are four measures of field length: content-word types, all word types, content-word tokens, and all word tokens.

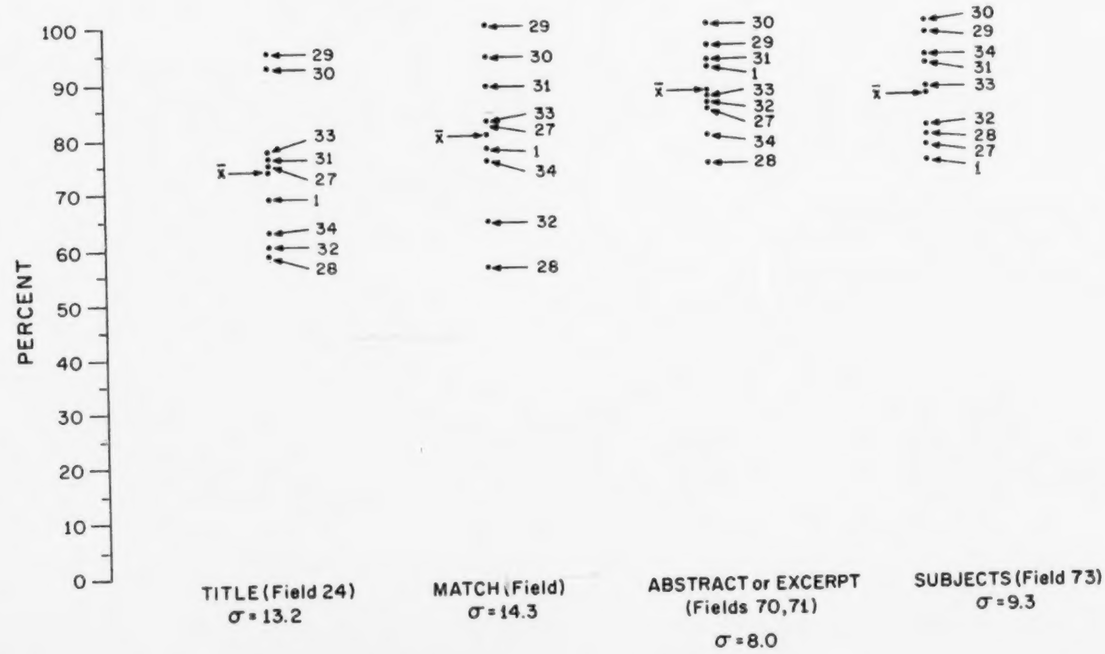


9 Experimental Subjects
(Designated by Number)

180 Documents

x̄ = Mean
σ = Standard Deviation

Fig. IIB-4 Percent of Concurrent Documents (Raw Data)



9 Experimental Subjects
(Designated by Number)

180 Documents

x̄ = Mean
σ = Standard Deviation

Fig. IIB-5 Percent of Concurrent Documents (Adjusted Data)

When counting word types we classify all words with the same stem as one type.† For present purposes we shall consider a noncontent word to be one of the 13 common words which Intrex excludes from the inverted files. These are "a", "and", "as", "at", "by", "for", "from", "in", "of", "on", "the", "to" and "with". We are currently investigating how our results would be affected by a generalization of the working definition of noncontent words. Examples of how the number of words is counted in particular phrases follow:

SF*sub 6* (one word)
liquid-vapor critical point (four words)
approximately equal to *+ or -* 0.26 (three words)
Al-Cu alloys (three words)
non-uniform fields (three words)

In an attempt to evaluate the validity of the length hypothesis, the field information from twenty of the 180 documents presented to the nine ESs was counted using the four above-mentioned measures of field length. The results are compiled in Table B-1.

Table B-1

Field Length of 20-Document Sample

		Content Types	Noncontent Types	Total Types	Content Tokens	Noncontent Tokens	Total Tokens
Title	Total	148	46	194	148	51	199
(Field 24)	Average	7.4	2.3	9.7	7.4	2.6	10.0
Match	Total	494	104	598	808	253	1061
(Field 74)	Average	24.7	5.2	29.9	40.4	12.6	53.0
Abstract or Excerpt	Total	1077	155	1232	1515	536	2051
(Fields 71,70)	Average	59.8	8.6	68.4	84.2	29.8	113.9
Subjects	Total	1098	169	1267	2233	699	2932
(Field 73)	Average	54.9	8.4	63.4	111.6	35.0	146.6

The twenty documents in this sample were picked to represent a cross-section of the topics of the nine ESs. Two documents were selected at random from the twenty documents of each of the nine ESs (a total of 18 documents from the entire 180 documents), and two documents were selected at random from the remaining 162 documents. Only eighteen of the twenty documents had abstracts. Figure IIB-6 displays the percent of concurrent ratings (raw and adjusted data) in the 20-document sample as a function of the average number of content-word types in the sample.[*]

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† For details of the stemming procedure, see Julie B. Lovins, "Development of a Stemming Algorithm", Mechanical Translation, Vols 1 and 2, pp. 22-31.

A count was also made of the number of word tokens in the fields of the 180 documents presented to the nine ESs. From the number of word tokens, the number of content-word types was estimated by assuming that the ratio of word tokens to content-word types in the 180 documents was the same as the ratio of word tokens to content-word types in the 20-document sample. Figure IIB-7 displays the percent of concurrent ratings (raw and adjusted data) for the 180 documents as a function of the estimated average number of content-word types in those documents. Figure IIB-8 graphs the percent of concurrent ratings (raw and adjusted data) for the 180 documents against the average number of word tokens in those documents.

An examination of Figs. IIB-6, 7 and 8 indicates that the length hypothesis is confirmed only when concurrence is plotted against estimated average number of content-word types for the 180 documents (Fig. IIB-7). Content-word types are undoubtedly the best measure of the amount of information in a field; it is understandable that the amount of information in a field should be related to the indicativity of that field. Even though concurrence is plotted against average number of content-word types in Fig. IIB-6, the small size of the sample (20 documents) might be responsible for the lack of confirmation of the length hypothesis (particularly with respect to the raw indicativity of matches and abstracts and the adjusted indicativity of abstracts). For actual verification of the length hypothesis, where length is measured in terms of content-word types, [illegible] actual count of content-word types in the 180 documents is necessary so that concurrence can be graphed against average number of content-word types for the larger sample.

When concurrence is plotted against average number of word tokens for the 180 documents (Fig. IIB-8), the only exception to the length hypothesis is provided by subject-index phrases — which are 12.4 words longer than abstracts on the average, yet are slightly lower in indicativity. Perhaps subject-index phrases are the exception because they are the one field in which substantial increase in word tokens is least likely to mean a substantial increase in the number of word types (particularly content-word types).

It is again emphasized that the Series B experiment is still in progress; the preceding material represents results to date.

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[*] The percent of concurrent ratings was taken as the measure of indicativity.

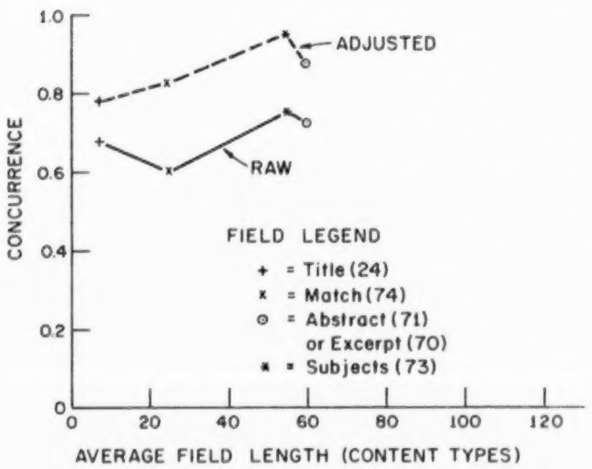

Fig. IIB-6 Concurrence as a Function of Average Number of Content-Word Types in a Sample of 20 Documents

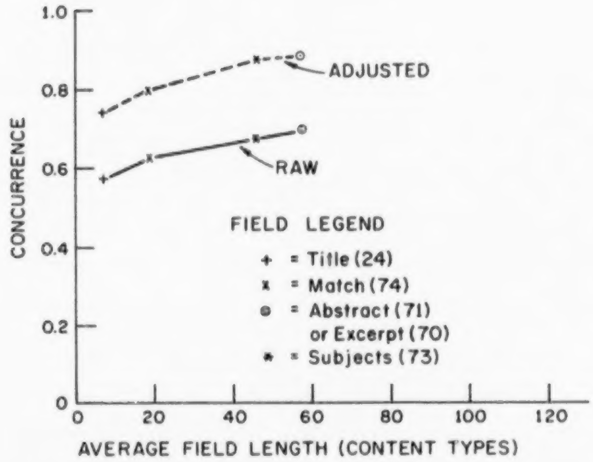

Fig. IIB-7 Concurrence as a Function of Estimated Average Number of Content-Word Types in 180 Documents

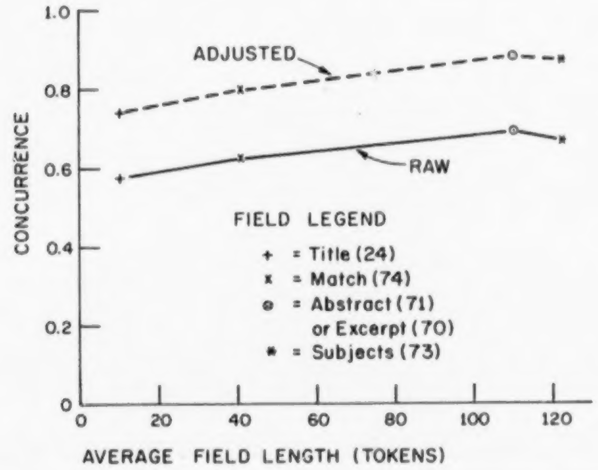

Fig. IIB-8 Concurrence as a Function of Average Number of Word Tokens in 180 Documents

THE CLASS EXPERIMENT: RETRIEVAL EFFECTIVENESS, INDEXING AND STRATEGY

A description of the procedures and initial results of the Class Experiment on Retrieval Effectiveness was given in the 15 March 1971 Semiannual Report. This section describes the further experimentation and analysis on one of the three topics of the Class Experiment, "irradiation embrittlement of metals", especially in regard to how retrieval effectiveness is influenced by type and depth of indexing and by type of search strategies. Excerpts of the analysis will be presented followed by a set of hypotheses generated as a result of this analysis.

Development of a Recall Base. The 27 Intrex references in the student's papers represent 14 different documents, of which 6 represent multiple uses. These 6 — let us call them Set M — were chosen for in-depth retrieval effectiveness analysis. Note that later evaluation by the experts showed that all six were very highly relevant and, perhaps, the most, highly relevant in the Intrex data base.

These six may be divided into two subsets: Subset A represents those in which irradiation embrittlement itself is discussed (D 3758, D 3329, and D 3299). Subset B (D 11208, D 8733, and D 7522) is made up of documents in which irradiation and some topic related to embrittlement are discussed.

Subset-A Searching. Let us first consider the strategy of searching on the two principle words "irradiation embrittlement". A search on this phrase yielded two documents in Intrex. Intrex recall for this search strategy with respect to Subset A is then 2/3 (0.67). No irrelevant documents were retrieved; precision is 2/2 = 1.0. The indexing depth required in Intrex to retrieve these documents is shown in Figs. IIB-9 and IIB-10. By range number one article is retrieved on title (range 5) and one more on range 2. By number of index words, one article is retrieved on 12 words* and another on 56. By depth of indexing normalized by length of text one article is retrieved on 12/2000 (about .005) indexing and the other on 56/2000 (about .028) indexing — both texts contained about 2000 words.

Indexing depth required by full-text-word indexing can also be considered. A simple form of this kind of indexing may be defined by taking each sentence in the article as a subject term. Also the title and other headings would be subject terms. Depth of indexing can be simply estimated by considering the order of indexing as going from the title to the abstract to the other headings and, finally to full text, from first sentence to last.

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* Note: all words, including common words, are included in this count.

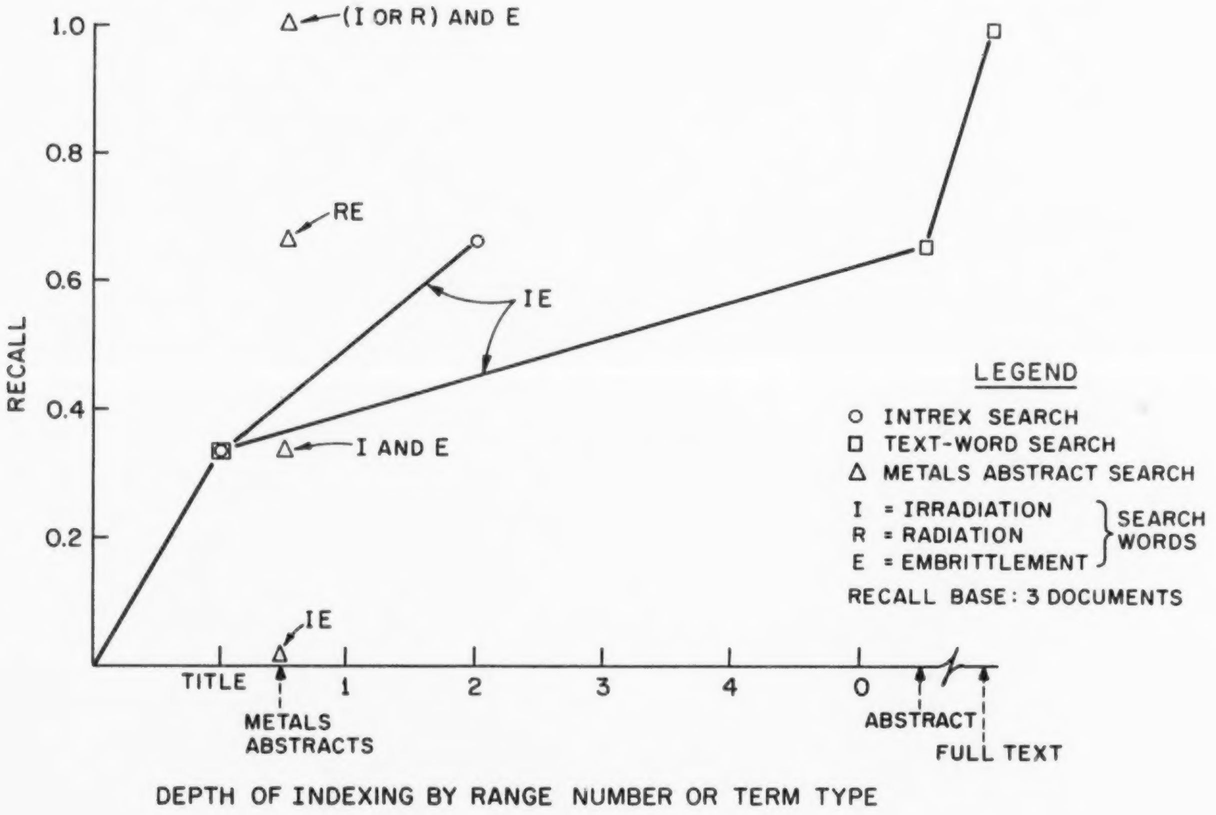

Fig. IIB-9 Recall as a Function of Depth by Term Type for Subset A Search

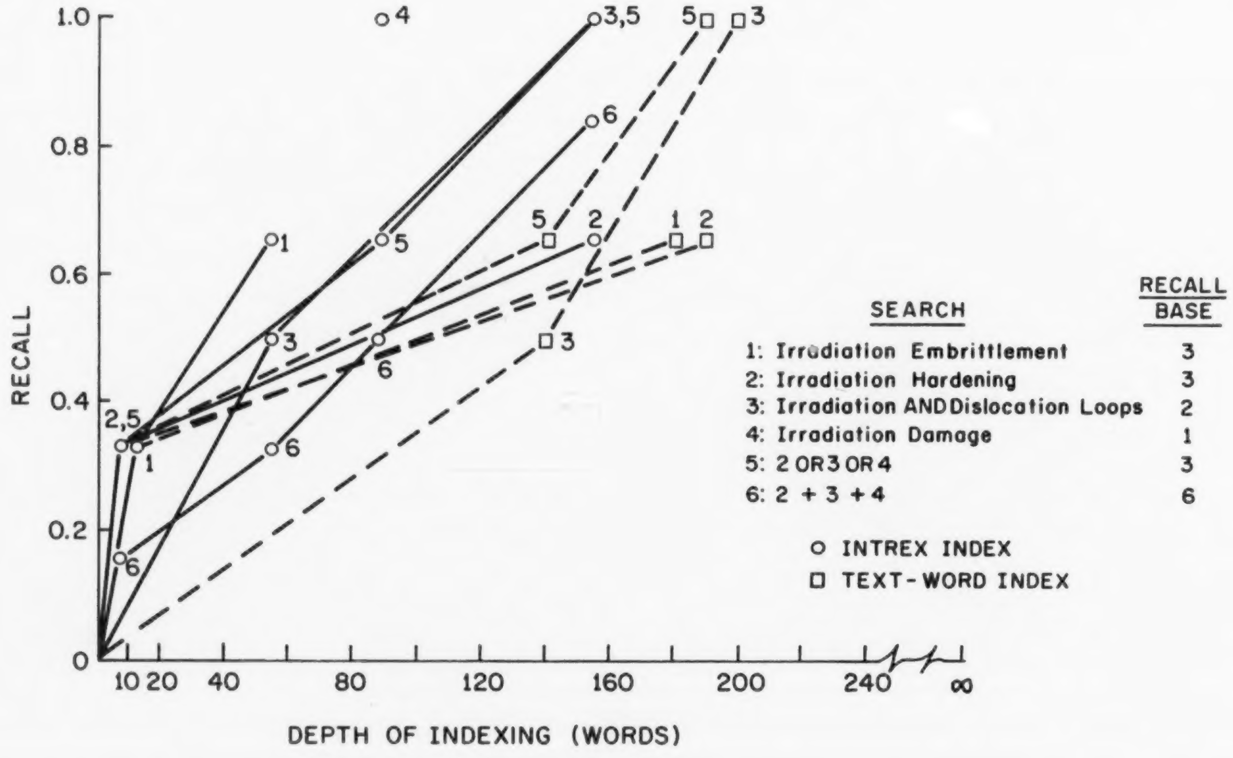

Fig. IIB-10 Recall as a Function of Depth (Absolute Words) for Subsets A and B

It is of interest to consider the importance of phrase decomposition and stemming in the matching algorithm. In only one of the three articles of Subset A does the precise phrase "irradiation embrittlement" appear. A similar statement can be made about the Intrex indexing, which is derived from the texts. In D 3329 it is necessary to use both phrase decomposition (word re-ordering) and stemming (irradi-ation = irradiated) to make the title match. Phrase decomposition alone would suffice if augmented by Boolean matching (irradiation AND embrittlement: the two words may appear in different subject terms) and the depth of indexing is increased to abstract level. D 3758 will match using just phrase decomposition on a sentence in the Summary of that document.

The full-text, automatic indexing depth required for retrieval assuming both phrase decomposition and stemming is, then, as follows: one document was retrieved with title (12 words, .006 depth). A second article was retrieved on abstract (about 150 words or about 150/2000 = .075 depth). A third article was retrieved in middle of text (about 1000 words or about 0.5 depth.)

A comparison of manual Intrex indexing with simple, automatic full-text indexing in this situation is consistent with results found from previous experience; namely, (1) title-word indexing is, of course, equivalent in both cases; (2) Intrex retrieval, measured by recall, is better for a given depth of indexing (measured by number of words or fractional indexing depth), or, said another way, one can get a given recall for fewer index words chosen by a human indexer; (3) eventually the great depth of full-text indexing achieves better recall than the limited-depth of the manual indexing. An explanation of point (2) of these results is that manual indexes can distinguish the important from the unimportant words in abstract and full text more effectively than simple automatic schemes. While more sophisticated automatic schemes would presumably, do much better, it is our impression from analyzing these sample cases that even the most sophisticated and complicated schemes that have been recommended to date would still not be as effective as manual indexing is.

Let us now consider the kinds of strategies required to search and retrieve these documents using the Metals Abstracts (MA) index. It may be observed first that a search under "irradiation embrittlement" with or without phrase decomposition and stemming will yield null results. The reason is simply that there is no MA index term "irradiation embrittlement" or a term with those words in it. There is one document, D 3329, which is indexed under the separate terms "irradiation" and "embrittlement" and could be retrieved by a Boolean AND on these terms. MA index terms often have a main heading followed by a comma and a subordinate heading. The term "radiation effects" is regularly used as a subordinate heading. The other two documents in Subset A can be retrieved under the heading "embrittlement, radiation effects".

Subset B Searching. Let us now consider retrieval of the 3 documents in Subset B. Three relevant terms were used in searching by the students:

Search (2)	Irradiation harden (ed, ing)	by ES A3 and ES A4.
Search (3)	Dislocation loops	by ES A4
Search (4)	(Radiation) damage	by ES A3

The Intrex search phrase "irradiation hardening" will retrieve just the one document, D7522, on the title. The Boolean combination "irradiation" and "hardening" will also retrieve D11208 on a range-3 term. By comparison, full-text search is equivalent on the original search and gets D 8733 on a Boolean search of the abstract. We may note that full-text search and Intrex search retrieve the same numbers of documents on each search. Intrex does not get D 8733 and full-text search misses D 11208, at least to abstract level. Comparative indexing depths required for retrieval are shown in Figs. IIB-10 and 11. MA indexing gets only D7522 with the terms "hardening, radiation effects"

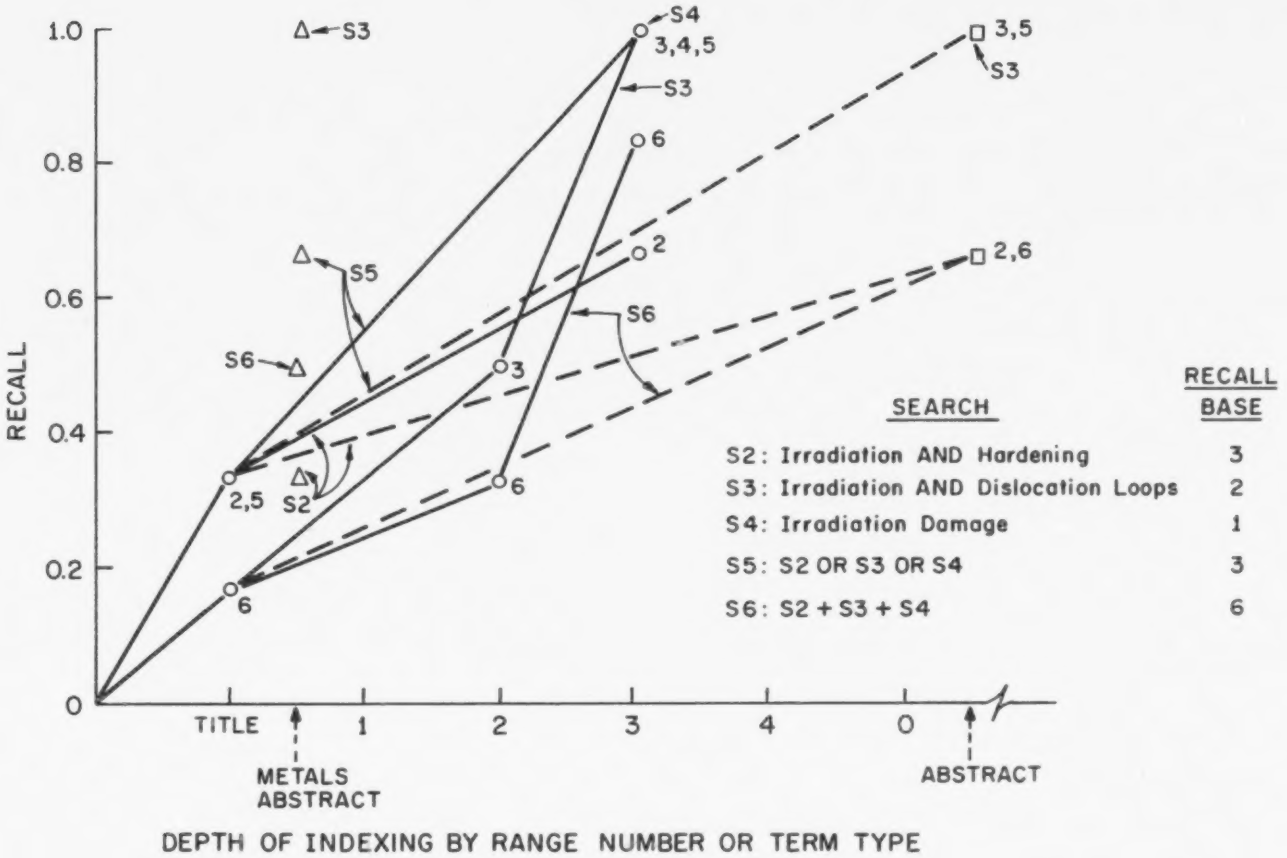

Fig. IIB-11 Recall as a Function of Depth by Term Type for Subset B Search

and "irradiation". The match here would necessitate either the Boolean combination "irradiation and Hardening" or the synomym "radiation" for "irradiation". By comparison here title-word indexing is equivalent to MA indexing and Intrex gives a 1.00 discovery ratio by going to deep indexing.

The search phrase "(irradiation or radiation) and dislocation loops" has results as follows. In Intrex, D7522 is retrieved on a range 2 term; neither Boolean relations nor synonyms are needed. D11208 is retrieved on a Boolean combination of a title term and a range 3 term. In no case does Intrex require the synonym "radiation". Both of these documents will also be retrieved by MA indexing. D7522 requires the Boolean and D11208 requires the synonym "radiation". The depth of indexing required is indicated on Figs. IIB-10 and IIB-11.

The search term "radiation damage" will not retrieve any of these 3 documents. However, "irradiation damage" will retrieve D8733 on a range 3 term. Neither abstract word or MA indexing will retrieval any of the 3 documents.

The above results on single searches may not be statistically significant because of the small number of documents involved. In order to summarize the results and to gain greater statistical significance, it is desirable to combine the results of the different searches. There are two ways to combine the results of these various searches in trying to get an overall picture, or average, of the results. The first is to consider a single search as the combination (logical OR) of the searches. The second is to sum the figures from the individual searches, with no deduction for the situation where a given document is retrieved more than once by different searches. The first kind of combination, shown by label 5 in Figs. IIB-10 and IIB-11 emphasizes the nature of the individual searches as part of a larger search. For the searches on Subset B the combined results by this method show one document found by Intrex (or full-text indexing) and not by MA, for a discovery ratio of 1/2 = 0.5. The second kind of combination emphasizes the variety evidenced by the individual searches in performing diverse searches. For Subset B label 6 on Figs. IIB-10 and IIB-11, we see a discovery ratio of 2/3 = 0.67.

The three searches mentioned above were made, in one form or another, by the one or more of the students. Two other searches, not actually made by the students but illustrating certain points, will now be considered. The first of these is on "(irradiation or radiation) AND slip". For this search Intrex retrieves D8733 on the title and D11208 on a range-1 term. While slip is obviously very important to D11208 and is the very first word in the text, it is not included in the 140-word abstract. MA also captures these two documents: D11208 on the single term "slip, radiation effects" and D8733 on the combination of two terms: "iron, irradiation" and "slip". We may note the importance of phrase decomposition here; the word "irradiation" is "hidden" as a secondary term to "iron". We also see how the secondary term here, where the primary term is a material rather than a property, shifts to "irradiation" from "radiation effects". This is another incation of the difficulty of adhering to a consistently standardized, controlled vocabulary.

This search term is illustrative of a term that is in the controlled vocabulary. For these terms MA indexing is very good; if the concept is important to the document, the chances are good that the document will be so indexed. "Hardening"; "dislocation loops", and "embrittlement" are comparable controlled-vocabulary terms in MA. The concept "irradiation" is an even more forceful example of this situation. MA not only uses the term as a primary term and a secondary term, if we consider "radiation effects" as equivalent, but it is also a classification term in MA.

The second illustrative search, "irradiation deformation", is an example of the case where the given term, "deformation", is not in the controlled vocabulary. D 11208 has this term in the title. D 8733 has this term in the abstract and in an Intrex range-3 term. It is, of course, not so indexed by MA. The fourth search term "radiation damage" is a somewhat intermediate situation. While this term itself is a vocabulary item, the unit term "damage" is not. Also, it appears that this concept is not nearly so throughly indexed as are other terms in the vocabulary, perhaps because the terms "radiation effects" or "irradiation" are regulary added as secondary terms. This is another example of the difficulty of trying to maintain a consistent indexing policy with a controlled vocabulary.

Detailed Analysis of Search on "Irradiation". In order to ascertain which other documents were relevant to the topic, the assistance of two experts in this topic were obtained: ES A5, the professor in charge of the course, and ES A6, a professor of nuclear engineering who had written the review of the topic used by ES A2. One or both of these experts were shown 37 documents for relevance rating. Sample ratings are shown in Fig. IIB-12. The rating scale was: 1, very highly relevant; 2, moderately relevant; 3, not-at-all relevant. Fractional ratings were allowed. 25 of the 37 documents had some relevance, that is, one or both experts gave a rating higher than 3.

Other documents considered for detailed analysis were the first 50 of the 191 on the irradiation list. Of these 50, 21 had been selected for Metallurgy groups and 30 for Physics groups — one was selected for both. An analysis of the 21 led to their categorization in two groups. The first group, numbering 11, had discussion of mechanical or structural properties and appeared highly relevant. The second group, with the other 10 documents, either did not directly discuss mechanical or structural properties or were felt to be of questionable relevance for other reasons, for example, the material in question was not a metal, the radiation involved was acoustic, etc. All these 10 were rated by both experts.

The analyst's judgment on the first group was partially verified when ES A6 gave two ratings of 1 and two ratings of 2 to selected documents in this group. The second group yielded ratings that ranged from 1 to 3, but there was a clear indication

The citation of each document is followed by the ratings given by the two experts ES A5 and ES A6. The ratings are: 1, highly relevant; 2, moderately relevant; and 3, not relevant. Any special comments by the experts or about the ratings are given in parentheses following the rating. Then follows the pertinent aspects of the indexing as done by Intrex, Metals abstracts (MA) and Physics Abstracts (PA). The letters "NA" following an index word indicate that that word is not found in the abstract. The number in parentheses immediately following the tag 'MA' or 'PA' is the identification number given to that document by the respective abstract journal. Finally, additional comments about the document, ratings, or indexing are sometimes given in a concluding paragraph. The information given in this figure is for a sample of two of the 37 documents rated by the experts.

D 11208: Deformation of Neutron-irradiated Copper Single Crystals; Sharp, J.V.; PHMAA. v.16, no.139, 070067. pp. 77-96.

ES A5: 1

ES A6: 1 (I know this one--D 11208 was in his bibliography)

INTREX: microscopy...(1); slip...(2); dislocation...(2); defect...(2); dislocation loop...(3); hardening...(3);

MA (M14 78909) dislocation loops, radiation effects; slip, radiation effects

PA (67-29615) neutrons and antineutrons, effects, ...deformation...

D11208 was in bibliographies of ES A4 and ES A6

D 11197; The Interaction between Dislocation Loops and Straight Dislocations in an Anisotropic Material, Graphite; Thrower, P.A.; PHMAA. v.15, no.134, 020067. pp. 341-352.

ES A5: 3 (on theoretical analysis of interactions of dislocation structures; only little experiment on irradiation)

ES A6: 1.5 (This was a hard decision)

INTREX: microscropic NA studies...vacancy of irradiated NA single NA crystal NA of graphite (2)

MA (67-05-M13-68758) dislocation loops

PA (67-23910) (not found under any radiation heading)

Fig. IIB-12 A Sample of Documents Rated by Experts that this group had significantly less relevance as a whole with an average rating of 2.2 for both experts compared to 1.3 for the first group.

Let us divide the relevance scale into ranges as follows:

Relevance (r) Range	Relevance
$r = 1$	V: very high relevance
$1 < r \leq 1.5$	H: high relevance
$1.5 < r < 2.5$	M: moderate relevance
$2.5 \leq r < 3$	S: slight relevance
$r = 3$	N: no relevance

Then the average ratings for the 21 documents broke down as follows: in the first group of eleven the ratings for the five judged by the experts were 2V, 1H, 2M; and for the second group the ratings were 2H, 5M, 1S, and 2N. Noting that these 2 groups are of about equal size, we have the following estimated averages of relevances for metallurgy documents chosen at random from the Intrex list on "irradiation":

V	20 percent
H	20 percent
M	45 percent
S	5 percent
N	10 percent

A detailed analysis was made of the 1540 documents found in Intrex under the terms "irradiation", "radiation", "neutron", and "nuclear reactor", especially the subset of 470 of those 1540 which also matched on one or more of 30 terms concerning mechanical or structural properties. The results showed that only a few documents not chosen for a metallurgy group were relevant and very few documents not indexed under "irradiation" were relevant.

Comparison of Retrieval Effectiveness on Radiation Terms. We shall now consider how retrieval is affected by the different kinds of indexing for the set of 37 documents rated by the experts of which 25 were rated as having some relevance. These documents will be considered in relation to their retrieval under the term "irradiation" or some other radiation term. The only exception to this is one irrelevant document which has no radiation relatedness and was retrieved under the term "embrittlement". Twenty nine of the other 36 documents were indexed by Intrex under the term "irradiation". Of the remaining seven, 6 were indexed under the term "radiation" and 1 was indexed under "neutron scattering" and "x-rays".

The depth of indexing required to retrieve the 25 relevant documents in Intrex is shown in Fig. IIB-13. We see that 64 percent of these documents were retrievable on title words; another 4 percent required range 1; another 28 percent required range 2; and the final 4 percent required an indexing depth of range 3.

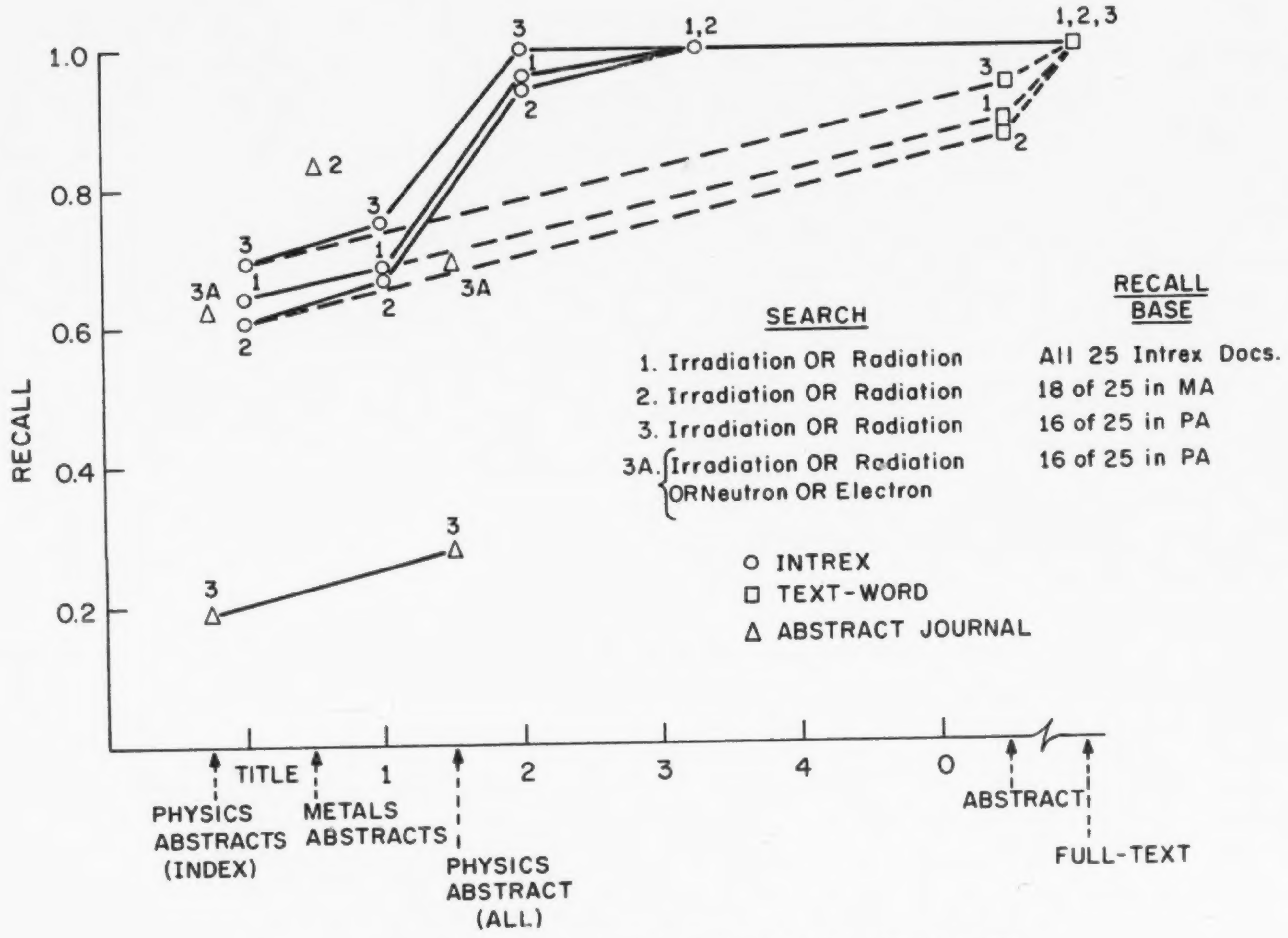

Fig. IIB-13 Recall as a Function of Depth (Term Type) for "Radiation" Search

The rather high retrieval effectiveness of the more important range terms seems to correspond previous experience with very simple (single-word) search strategies. More complicated strategies, as required in the retrieval described earlier on subsets A and B, seem to demand deeper indexing for a given recall.

The indexing depth required of automatic text indexing is also seen in Fig. IIB-13. Besides the 16 title retrievals (64 percent) there are 6 retrievals (24 percent) that require abstract words, and 3 (12 percent) that require matching on text words found in neither title nor abstract. In fact one document of the last three had no abstract.

It is of interest to see how the highest depth of indexing required for retrieval correlates with relevance. Dividing the relevance scale into high, moderate (or slight), and no relevance as we did before, we find that of the 11 documents rated in the high-relevance category only 3 (27 percent) required greater than title depth (one required range 1, two need range-2 depth). However, of the 14 moderately relevant documents there were 6 (43 percent) that required greater-than-title depth (5 needed range-2 depth, one needed range 3). Looking at the 12 non-relevant documents, we see 9 (75 percent) that were retrieved on greater-than-title depth and 5 (42 percent) were retrieved on range 3. A similar picture is seen for the automatic-indexing depths. In the high relevance range only 2 documents (18 percent) required abstract words and only 1 (9 percent) deep text. On the moderate relevance category there were 4 requiring abstract words (29 percent) and 2 requiring deep text words (14 percent). In the no-relevance category 5 documents were retrieved on abstract words (42 percent) and 4 on deep text words (33 percent).

In summary, we see that these results are in conformity with those on other searches and show that depth of indexing is very definitely and significantly correlated with relevance. However, these results also showed that it is not possible for a searcher to make restrictions on depth of matching terms without incurring definite risks in terms of lower recall.

We shall now consider how Abstract Journal indexing on the set of 25 relevant documents compares with the indexing just described. Of the 25 documents in the set, 18 were found in Metals Abstracts. Of the 7 not found in MA all but 2 were in journals from which MA does not select. Of the 18 found in MA, 15 were indexed by MA by some kind of "radiation" term. Of the three that were not — representing a discovery ratio for Intrex of 3/16 = 19 percent — one had a moderately-high relevance with a range-3 Intrex match and a deep text-word match; a second also had moderately high relevance with deep text-word match but range-2 Intrex match, and the other had slight relevance with title-word match. These results suggest that for a topic like "irradiation" which is well-covered by the controlled vocubulary MA not only does about as well for recall as Intrex for the highly relevant documents but also does rather well for moderate to slightly relevant documents as seen by the relatively low discovery ratio of 19 percent.

It is of interest to observe the depth of indexing required to achieve a given recall on the base of 18 documents. Figure IIB-13 shows that recall level of MA is achieved at a depth of Intrex indexing between range 1 and range 2. We note that the 3 documents missed by MA had a lower-than-average relevance and also required deeper indexing for retrieval than the average depth required in this set of 18.

Physics Abstracts (PA) indexing for these documents was also considered. PA indexing differs from MA indexing in several respects. PA indexing averages about

2.5 entries per document, whereas MA averages about 4.7. A PA index term tends to be longer than that of MA: about 3 words for PA compared to about 2 for MA. Overall, the depth of indexing, in terms of number of English words, appears somewhat greater for MA (about 10 to 12 words) compared to PA (about 7 or 8 words). On the depth-of-indexing scale of Fig. IIB-13 this places the PA indexing somewhat shallower that title-word indexing and MA indexing somewhat deeper. The PA index, in addition to the subject-index term itself, is followed by a series of added keywords, often taken largely from the title, for additional specification of subject content. It is worthwhile to consider retrieval effectiveness based on this augmented PA indexing, although PA itself, either in the printed version or the INSPEC tapes, does not provide any facility for primary searching on their added keywords. We estimate the supplementary keywords would add about ten to fifteen words onto the 7 or 8 regular index words, thus bringing the total word-depth to about 15 to 25 words. We place these numbers between the range-1 and range-3 depth on the Intrex depth scale. The redundancy factor of these words is probably fairly high, as it is in Intrex, since title words will tend to be repeated in the keyword expansions.

The controlled vocabulary in PA is clearly less detailed in the irradiation-embrittlement topic than is the MA vocabulary, as one would expect. Neither "irradiation" nor "embrittlement" as such, appear in any subject term. The PA index vocabulary fits with the structure of the PA subject classification scheme. The main classification of relevance to this topic is "Solid State Structures and Mechanical Properties", and, in particular, the sub-class within this class called "Radiation Interaction with Solids". The index terms that appear most appropriate are the general term "physical effects of radiation" and the terms specifically mentioning the kind of radiation including "neutrons and antineutrons effects", "electron beam effects", and "acoustic waves, effects." The term "radiation damage" is not an index term itself but the PA index-vocabulary explanation includes it as a "lead-in" term with a: see reference to "physical effects of radiation". Similarly, "irradiation effects" has a see reference to this term plus ones to corresponding terms in biological and chemical effects of radiation. It may be noted that no indexing outside the PA solid-state classification seemed to yield any documents relevant to the topic.

With this background we can now summarize the retrieval effectiveness of PA compared with Intrex. Of the 25 relevant documents, 16 (64 percent) were found in PA. As far as searching for a radiation-related terms in the controlled vocabulary of PA, we find that there are 3 of the 16 documents found in PA which are indexed under a term with the word "radiation". Another 7 are indexed under a more specific term containing either "neutron" or "electron beam". Thus the discovery ratio for Intrex is either 13/3 = 4.3 or 6/10 = 0.6 depending on which search strategy is considered. If we consider the results obtainable when the added keywords are also included, we find 6 documents indexed by either "radiation" or "irradiation" and a total of 11 indexed by either of these words or one of the specific radiation words mentioned above.

There is an obvious correlation between the PA indexing and title words: of the 5 documents missed by PA, 4 required non-title words for retrieval and only 1 other document of the 16 required such non-title words for retrieval, and was retrieved by PA, and that on an added keyword. Thus depth of indexing is again clearly a major factor in improved recall by Intrex.

PA indexing is clearly much less effective than MA indexing for the topic "irradiation embrittlement". This fact bears on another difficulty of the controlled-vocabulary approach to indexing: the difficulty of applying the vocabulary derived for one subject area (here physics) to another, even closely related, area (here metallurgy). The whole emphasis is obviously shifted. For example, the word "irradiation" is not at all used in the controlled vocabulary and where radiation is referred to it is more often referred to by the specific type of radiation (neutrons, electrons) rather than generically as "radiation". On the other hand, the mechanical properties are regularly included under such generic headings as "physical effects" or just "effects" and there is no way to get specific about such subjects as "embrittlement" or "fracture". These particular difficulties point up another kind of problem in applying a controlled vocabulary to indexing: the generic-specific dilemma. Whereas the controlled-vocabulary approach may (artificially) emphasize some point on a classification hierarchy (often the more generic), the free-vocabulary approach naturally used that level of specificity given by the author and presumably, most descriptive of the level at which he is actually working. In any case, the results here further strengthen the case for using the free vocabulary of the author as best suited to the retrieval needs of a searcher.

Inconsistency in Relevance Ratings. Of the 37 documents rated by the experts, 11 were rated by only one expert and 26 were rated by both. Looking at these 26 documents that both experts rated, we can measure the inconsistencies of rating. Fifteen of the 26 (58 percent) were rated differently by the two experts. These differences were not insignificant. The average (absolute) difference numerically was 0.88. In ten instances the difference was greater than 0.5 and in 8 cases it was greater or equal to 1.0 which corresponds to the difference, for example, between very highly relevant and moderately relevant or between moderately relevant and not relevant. In one case the difference was 2: one expert said very highly relevant and the other said not-at-all relevant! The average difference, counting all 26 mutual ratings, is 0.58. A small part of the difference can be attributed to a bias on the part of ES A5 to rate higher than ES A6 which he did on 13 occasions while he gave a lower rating on only 4 occasions. However, the average amount by which ES A5 rated documents higher than ES A6 over all 26 documents is only 0.15.

Besides inter-rater inconsistency we also note some intra-rater inconsistency: namely, an expert changing his rating for one reason or another. Of the 52 individual ratings by both experts there was a change made in 7 (14 percent) of the cases, including five cases of raising the rating and two of lowering. The average absolute difference in rating in these seven cases was 0.7, or about 0.1 when averaged over all 52 ratings.

Previous analysis of inter-rating inconsistency have suggested that the main source of inconsistency comes from documents that are somewhat lower on the relevance scale than the core of highly relevant documents. While this seems highly plausible and may be true in some sense, there is evidence in our results that at least some documents rated highly relevant by one expert will be rated only slightly, or not-at-all, relevant by a second expert.

These results suggest that the core of incontrovertibly highly relevant documents may have to be more narrowly defined. In this case experts might agree that highly relevant documents are those that clearly and explicitly discuss the embrittling or fracturing effects of neutron or electron irradiation on structural metals or alloys.

Search Strategies. In looking over the various search results, we conclude that the searching strategy employed has a major effect on the retrieval effectiveness. Search strategy has to do with the search words themselves, how they are related semantically and morphologically to the words of the topic description, how they are combined to form search requests, the order in which the requests are made, and the kind of output looked at from each request. While the kind of indexing and the depth of indexing also have important effects on the retrieval by varying degrees as shown by the figures, the search strategy has critical and overwhelming effects. For example, the simple topic description "irradiation embrittlement of metals" gives no documents at all; "metals" is a poor term and its use in combination with other terms cuts down recall greatly without aiding precision; too many (even "good") terms like "brittle fracture irradiation" as used by ES A2, when used together, give no documents unless proper Booleans are used — e.g., "irradiation AND (brittle or fracture)". Thus, what are good strategies and how to arrive at them are critical questions.

Other words and their combinations are illustrative of strategy consideration. We have previously described how the term "irradiation" had a high recall and relatively high precision even by itself, whereas related words like "radiation" gave poor recall and precision. The word "embrittlement" provides good precision but poor recall in combination with irradiation and poor precision and recall alone. Expanding the search to the eight most promising mechanical properties other than "embrittlement" itself gave no more than about one-third of the relevant documents. While these results should be extended and refined quantitatively, it appears that when a simple, single-word search term suffices (for example "irradiation" or "fatigue"), then the improvement in retrieval effectiveness tails off rather sharply as indexing depth is increased; however, when the search requires a combination of several terms or concepts, then retrieval effectiveness can increase as a function of depth of indexing.

The plausibility of such an hypothesis is demonstrated by considering the following simplified situation: Assume a search on two coordinate concepts, A and B. Assume further that the probability of an indexer using term A for a document for which term A is relevant is (close to) linearly proportional to depth of indexing, at least for small depths. Assume a similar and independent situation for term B. Then the probability of retrieving any relevant document is proportional to the square of the depth of indexing, thus possibly counteracting the law of diminishing returns for certain ranges of the depth parameter.

There appear to be two different optimal strategies. If high recall is desired, then the use of the single term "irradition" is indicated. For this simple strategy the precision at a high-relevance level will be rather small while precision at a moderate-relevance level will be about equal to the proportion of metallurgy documents indexed under "irradiation" in the data base — about 40 percent for Intrex. An obvious major improvement to this strategy would be to select only the metallurgy documents, that is, coordinate "subject: irradiation" and "subject area: metallurgy". This could be done either manually or automatically (with successive RESTRICT commands) by selecting only a metallurgy group in Catalog Field 2 (CHOSEN FOR). This conclusion suggests that for data bases with multiple-subject areas it would be very valuable to have at least a gross classification scheme within the inverted-file indexing. If there were not too many classes involved, it might be more efficient to store this information within each inverted-file reference rather than as a separate term for each document — the latter implementation would require extensive intersecting of large lists.

If high relevance is desired and moderate recall is acceptable, then the second optimal strategy of coordination of the term "irradiation" with "embrittlement" and several other terms related to "embrittlement" is suggested. How far to extend the embrittlement-related terms, whether to other mechanical or structural properties (e.g., brittle, fracture, dislocation loops, helium bubbles) would depend on the level of recall desired and on which of these terms met the users personal notion of high relevance to the topic.

The students' strategies were fairly effective in locating most of the potentially relevant documents although they were often inefficient. (see Tables B-2 and B-3). The reason, then, that the students selected relatively few documents had to do more with their motivation than their strategy. The students either misunderstood the instruction to be comprehensive or, more likely, felt they did not have sufficient time to be any more comprehensive than they were. One reason the students may have succeeded as well as they did in finding good strategies was that the pre-Intrex briefing and demonstration that each was given emphasized searching techniques. On the other hand, Intrex analysts were instructed not to coach students on strategies after the actual Intrex sessions started and the amount of help actually given was kept small. We may conclude that the kind of Intrex instruction available to the students, especially the amount of pre-session coaching, was sufficient to lead to effective, if not very efficient, strategies.

Table B-2

Excerpt from Strategy of Student ES A3

search[1]	number[2]	no. out[3]	fields[4]
irradiation embrittlement metals	0		
irradiation embrittlement = george	2	2	76; all
d 3329	(1)	1	90
(george)	(2)	2	73
irradiation helium	4	4	24
d 3758	(1)	1	71; 70; 5, 73
neutron irradiation	56		
neutron irradiation metal embrittlement	0		
neutron irradiation	56	31	24
a roy, r.b.	7	7	24
d 3758	(1)	1	5
a solly, b	2		
. . .			

NOTES

(1) Subject search assumed unless otherwise specified. Naming of list indicating by "="; restoring list by name in parentheses.

(2) Number of documents found in search.

(3) Number of documents looked at via output command.

(4) The fields looked at via output command; semi-colon separation indicates separate output command on same list.

Table B-3

Words Used in Student Subject Searches

Word	Subject ES A y			
y =	1	2	3	4
irradiation	X	X	X	X
radiation	X	X	X	
neutron		X	X	
nuclear reactor	X		X	
embrittlement	X	X	X	X
fracture		X		
brittle		X	X	
ductility			X	X
toughness			X	
hard -(en, ness)			X	
damage			X	
welds		X		
dislocation loops				X
voids			X	
wedge cracks				X
grain boundary preciptates				X
metals	X	X	X	
steel			X	
helium (bubbles)			X	X
hydrogen			X	
transmutation reaction				X
effects			X	
TOTAL TERMS: 22 (31 words)	5	8	16	8

Summary. The results of this analysis, together with the results from other experiments, are now leading to a set of hypotheses, outlined below, which if ultimately proven correct, give answers to many of the main questions concerning indexing and searching that we have been considering. The further quantification and testing of these hypotheses is being undertaken through the continued analysis of the other two topics on the class experiment and by means of other experiments.

The first three hypotheses have to do with the methodology and general background of the analysis.

1. Experimental Methods. Certain of the experimental and analytical methods employed herein have proved valuable and should be useful in the future not only for Intrex Experiments but to others who may be planning similar experiments. These include the development of a recall base, the use of experts for relevance judgments, the measurements of recall as a function of depth and strategies, and the use of certain analyst-derived searches.
2. Relevance-Rating Inconsistency. The variations in relevance ratings among users are significant and need to be taken into account. The means to measure this inconsistency was demonstrated in this study.
3. User Motivation. It was clearly demonstrated that the user's motivation will strongly influence his overall strategy, especially in its comprehensiveness.

The other hypotheses relate more directly to system evaluation itself.

4. Importance of Search Strategy. Search strategy is of overriding importance for retrieval effectiveness. The incorrect application of the various elements of strategy can cause effectiveness to drop to zero or, at least, cause great inefficiencies for the user and any retrieval system. Much future work needs to be centered on the quantification of various aspects of search strategy, in particular: how to measure how complex a strategy is and how difficult it is for a user to derive the strategy. Also, the obvious large differences in the search effectiveness of particular words, or types of words, need careful analysis to see how the good search words can be determined, especially by a user.

5. Free-Vocabulary vs. Controlled-Vocabulary Indexing. Free-vocabulary indexing has a marked advantage over controlled-vocabulary indexing because the free-vocabulary makes it much easier for the user to formulate good search strategies. In addition, the supposed normalizing effect of controlled vocabulary does not work in practice any better than for a free vocabulary. Moreover, free vocabulary is much better for the indexing of cross-disciplinary and new fields than a controlled-vocabulary for a given field and it is much easier to maintain as fields change in time. There is a definite loss of information inherent in the indexer and the user translating into an artificial controlled vocabulary.

6. Depth of Indexing. The law of diminishing returns as applied to retrieval effectiveness versus depth of indexing is substantiated, but only, in general, for simple, single-word searches. Here title words plus a few keywords-from-abstract retrieve a large percentage (perhaps 60 to 80 percent) of all relevant documents. However, a contrary effect takes place in some instances for more complex, multi-word searches. Here the effect of additional related words brought in by the deeper indexing sometimes makes a given retrieval effectiveness achievable by much simpler search strategies. Since, as indicated in point (4) above, the formulation of search strategies is crucial to retrieval effectiveness, there is a trade-off involved between the cost of deeper indexing to ease the strategy problem and the cost of efforts to instruct the user — for example, by thesaurus methods — in optimal strategy formulation. In any case, the best measure of depth is the number of word-stem types.

7. Manual vs. Automatic Indexing. Manual indexing has the advantage over simple, automatic indexing of achieving a given recall for a smaller depth of indexing. Indeed, there is no known automatic algorithm which is as good as human indexing in picking out the most important words first.

8. Abstract Journal Indexing. Abstract journals have the disadvantages of controlled-vocabulary and shallow indexing as indicated in points (5) and (6) above. However, within these limitations, these journals do a good job in capturing the most important document concepts.

9. Importance of Stemming and Phrase Decomposition. The type of stemming and phrase decomposition used by Intrex is highly necessary and effective, not only for Intrex indexing and searching itself, but also for searching done on non-Intrex indexed documents. Here again, the importance of controlling for possible variations in the user vocabulary and the index vocabulary as is accomplished by these two devices, plays an important role in achieving effective retrieval.

10. Precision-Controlling Factors. Controlling the Intrex algorithm for matching search requests based on criteria such as Intrex term range numbers, word order, word-in-term or word-not-in-term, or depth of indexing has a definite, but limited utility as means to control precision. While precision can be controlled to a certain extent by these devices there is a large effect in terms of loss of recall to be considered. On the other hand, when searching through a subset of documents of generally low relevance, these devices and, indeed, user-control over the stemming algorithm, become more critical.

11. Data-Base Compartmentalization. It is evident that a certain amount of compartmentalization — for example, as between Physics and Metallurgy — can sometimes yield important improvements in retrieval effectiveness by the elimination of large numbers of irrelevant documents. The use of a gross classification scheme is one means to achieve the needed logical compartmentalizing. It is felt important, on the other hand, not to have too great a physical compartmentalization for even though some searches may be improved greatly, this same effect can be achieved by the logical labeling and other searches would definitely require interdisciplinary searching which would be prevented with a physical separation. Also, it is important not to overemphasize the "numbers syndrome." For even in those topics where only a few Physics articles seem important, who can say what the value of one lost document really may be, especially one found serendipitously in an area not expected and one that could lead to a cross fertilization of areas originally thought independent of each other in a given problem?

THE CLASS EXPERIMENT: RETRIEVAL RATES FOR SEVERAL SEARCH SYSTEMS

The Semiannual Report of 15 March 1971, contained a preliminary discussion concerning the effectiveness of different search methods employed by the students in the Class Experiment. The factors underlying the raw data reported previously have been further analyzed, a methodology for studying comparative rates of retrieval effectiveness between different retrieval systems has been devised, and this methodology has been applied to the Class Experiment.

General Methodology for Comparing Retrieval Rates Between Systems. Comparing the effectiveness of different retrieval systems is a complex task. Given a searcher who uses two different retrieval systems, how can the effectiveness of these systems be compared? Several measures can each shed light on different aspects of complex system behavior. Two widely used measures are recall and precision. However, neither measure considers search-time effectiveness or rates of retrieval of useful items. The measure that we have chosen is the number of useful references found per search-hour invested. We feel this one measure summarizes rather well the direct benefit/cost ratio of a retrieval system for the individual user.

Before we consider the analysis of the Class Experiment retrieval rates, we shall discuss five general factors which affect this type of comparison among different retrieval systems. It is clear that the best comparison is achieved when the same search problem is searched by the same searcher in the different systems.

1. It is therefore important that the individual searcher's basic criteria defining a "useful retrieved document" remain constant for each retrieval system used for his search problem. In the Class Experiment, useful retrieved documents were taken as those documents actually used in preparing a term paper and which were cited in the bibliography of the paper. The possibility that some cited documents were actually more useful than others, or that the number of cited documents might not be a good measure of utility of retrieval systems in some cases, must be considered as assessing the applicability of this measure.
2. What exactly the retrieval system is and what its components are must be analyzed. This is particularly important when a system is in actuality a complex combination of several retrieval methods. At the most major level, does the system include only search and perusal of document surrogate components, or does it also include text retrieval and perusal of

text? In the Class Experiment we have defined each system to include only those aspects associated with searching. Even at the level of conducting searches only, components which may act in a different manner need to be analyzed individually for their effect on total system performance. For example, a library search may be composed of, among other things, searches in a number of different indices and catalogs, of browsing in the stacks, and of a reference-type telephone call. A more subtle aspect of system definition is the treatment accorded to documents which are indirectly found through a system, such as those retrieved from a list of references within a directly retrieved document.

3. The size and content of a data base will, of course, have an effect on the performance of a retrieval system. However, it is not yet at all clear how to normalize the effects of different size data bases, especially in an interactive environment where search strategy will likely depend significantly on the size of resulting search lists. One possibility for normalizing data base size differences is to incorporate some measure such as an average list size for the given search topic.

4. The bibliographic units that are counted must be normalized to accommodate systems that may or may not analyze composite volumes. This problem is another form of direct versus indirect retrieval. It has led us to develop a measure of adjusted useful references found which is discussed below in more detail in connection with the Class Experiment.

5. The time units that are counted for a complex system must be properly distributed over the components of the system. In the Class Experiment study, time spent accessing or reading text has been subtracted out because the definitions of each system relate only to search modes. However, we do consider browsing among text to be a form of search mode. Search times may still need to be adjusted in some cases for factors such as, for example, instruction time.

Once the proper normalizations have been made in the categories discussed above, retrieval rate comparisons between systems can be studied and analyzed with respect to the effects of variables such as: search strategy, search topic, searcher's motivation or purpose, searcher's proficiency, kind and depth of indexing, and data base size. The application of this methodology to the Class Experiment, described below, has been useful in reaching a better understanding of the retrieval systems being studied. In addition, this analysis should also be useful in the development of more refined methodologies for comparing the effectiveness of different retrieval systems, especially in terms of retrieval rates.

Application of the Methodology to the Class Experiment. Table B-4 is an updated, more detailed, presentation of the experimental data than the tabulation given in the 15 March 1971 Semiannual Report. The data in Table B-4 now account for the following factors:

1. The time spent reading text which is included in the gross time spent on Intrex has been subtracted out in order to make both the Intrex and the non-Intrex search modes more comparable. Data reported for the non-Intrex search modes do not include, as far as can be determined, time spent on document text accessing and reading.
2. Adjustments for time spent by a searcher in an instructional mode were not made to the time data in the Class Experiment other than excluding the initial demonstration given to each student prior to his Intrex search. (See the previous Semiannual Report for full details on the experimental protocol.) Although an analyst was present during Intrex searches, we estimate that considerably less than 10 percent of the search time was spent solely in receiving instruction and we note that the analysts themselves were instructed to encourage self-instruction. The self-instructional mode was primarily used by students in non-Intrex searches, although in a few instances, questions mostly of a "Where can I locate this abstract journal?" nature were posed to the library staff.
3. What was previously reported as library search results has now been separated into the categories of library index searches and non-index searches. This enables us to give a better comparison between the Intrex catalog searching, which is based on the inverted file, and the library index tools which have been further divided into the card catalog and all other indexed abstract journals. However, the non-index category has not been subdivided into its several components because the time data from this particular experiment was not well controlled for that mode. Nevertheless, some

Table B-4 Statistics on the Class Experiment and Retrieval Rates

STATISTIC	STUDENT AND SEARCH TOPIC(1)											Averages for Students Who First Searched Intrex(6)	Averages for Students Who First Searched Library (5)(6)	Averages for All Students (5)(6)
	A1	A2(5)	A3	A4	B1	B2	B3(5)	B4	B5	C1	C2			
Total References Used in Term Paper	12	12	39	52	19	33	37	20	16	4	16	18.3	33.7	23.4
First Searched Intrex (I) or Library (L)	I	L	I	L	I	L	L	I	I	I	L			
Intrex Searches														
-No. of Sessions	3	1	2	1	2	1	1	2	2	1	5	2.0	2.3	2.1
-Total Time (Catalog plus Text)(hours at console)	5.2	1.6	4.6	2.5	4.8	5.5	2.5	3.2	6.5	1.8	13.3	4.4	7.1	5.3
-Catalog Mode Time (hours at console)	3.7	1.3	4.4	2.0	4.1	3.7	2.4	2.9	5.6-	1.3	6.4	3.7	4.0	3.8
-Adjusted Useful References	4	2	4	9	7	14	0	0	10	2	5	4.8	9.3	6.1
Non-Intrex Searches (Library Mode plus Non-Index Mode)														
-Total Time (hours)	3+(2)	1++	15+	8.5+	3.8+	8+	8.5-35	3	1+	1+	26	4.5+	14.2+	7.7+
-Adjusted Useful References	8	10	38	46	12	19	38	20	6	2	11	14.3	25.3	18.0
Library Index Searches														
-Total Time (hours)	3-	1++	15	8.5+	1.0	5+	8-35	-	-	-	26	6.3[3]	13.2+	9.8[6]
-Total Adjusted Useful References	1	2	14	30	2	6	26	-	-	-	11	5.7[3]	15.7	10.7[6]
-Card Catalog Time (hours)	3	-	3	2	-	-	-	-	-	-	3	3.0[2]	2.5[2]	2.8[4]
-Adjusted Useful References from Card Catalog	1	-	7	1	-	-	-	-	-	-	1	4.0[2]	1.0[2]	2.5[4]
-Indexing Services Time (hours)	-	1++	12	6.5+	1	5+	8-35	-	-	-	23	6.5[2]	11.5	9.3[5]
-Adjusted Useful References from Services	-	2	7	29	2	6	26	-	-	-	10	4.5[2]	15.0	10.8[5]
Non-Index Searches														
-Total Time (hours)	ND(3)	ND	ND	ND	2.8+	3-	0.5++	3	1+	1+	-	2.6+[3]	3.0-[1]	2.7[4]
-Adjusted Useful References	7	8	24	16	10	13	12	20	6	2	-	11.5	14.5[2]	13.3[8]
All Search Modes														
-Total Time (hours)	6.7+	2.3++	19.4+	10.5+	7.9+	11.7+	10.9-37.4	5.9	6.6+	2.3+	33.4	8.1	18.5+	11.6+
-Adjusted Total Useful References	12	12	42	55	19	33	38	20	16	4	16	18.8	34.7	24.1
Adjusted Useful References per Search Hour														
-Intrex Mode	1.1	1.5	0.9	4.5	1.7	3.8	0	0	1.8+	1.5	0.8	1.2	3.0	1.8
-Non-Intrex Modes	2.7-	10--	2.5-	5.4-	3.2-	2.4-	4.5-1.1	6.7	6.0-	2.0-	0.4	[illegible]	2.7-	3.5 -
--Library Index Modes	0.3+	2--	0.9	3.5-	2.0-	1.2-	3.3-0.7	-	-	-	0.4	1.1[3]	1.7-	1.4 [6]
---Card Catalog Mode	0.3+	-	2.3	0.5	-	-	-	-	-	-	0.3	1.3+	0.4	0.9+
---Indexing Services Mode	-	2--	0.6	4.5-	2.0	1.2-	3.3-0.7	-	-	-	0.4	1.3	2.0-	1.7 -
--Non-Index Mode	ND	ND	ND	ND	3.6-	4.3+	24--	6.7	6.0	2.0-	-	4.6-[4]	4.3+	4.5 [5]
-All Modes	1.8-	5.2--	2.2-	5.2-	2.4-	2.8-	3.5-1.0	3.4	2.4-	1.7-	0.5	2.3-	2.8-	2.5-
Sources of References Found by Non-Index Searches (4)	4L, 3P	2C, 2T,4U	17A,1C, 4T,2U	6A, 5B,5U	2B,2C 3P,3U	3B,6M, 1T,3U	4A, 7C,1U	2C, 14M,4U	2C, 1P,3M	2U	-	2.8A, 0.3B, 1.2C, 1.2P, 0.7L, 2.8M, 0.7T, 1.8U	3.0A, 4.0B, 3.0M, 0.5T, [2] 4.0U	2.9A, 1.3B, 0.9C, 0.5L, 2.9M, 0.9P, [8] 0.6T, 2.4U
Intrex Text Mode (hours at console)	1.5	0.3	0.2	0.5	0.7	1.8	0.1	0.3	0.9+	0.5	6.9	0.7	3.1	1.5

NOTES:

1. Search topics are indicated by the student code letters:

    A - Irradiation embrittlement of metals
    B - Effect of microstructure on the fracture toughness of steels
    C - Effect of processing history on the fracture toughness of aluminum alloys.

2. Precise search times were not always determinable.

    + indicates the actual value is slightly higher than the given value
    - indicates the actual value is slightly lower than the given value
    ++ indicates the actual value is much greater than the given value
    -- indicates the actual value is much less than the given value

3. ND indicates that the value was not determined

4. Sources of references found by non-index searches are coded as:

    A - an analytic from a directly found library source
    B - library sources found by browsing in the stacks
    C - class text, class handout, or a reference taken from them
    I - a reference from within an Intrex retrieved document
    L - a reference from within a library retrieved document
    M - documents from the Professor's library, or a reference taken from them
    P - documents in the student's personal library, or a reference taken from them
    T - personal communication, or a reference from within such retrieved documents
    U - undetermined source

5. Data for students A2 and B3 are excluded from all summary calculations for reasons given in the text.

6. A number in brackets indicates the number of students over which data for a statistic has been calculated when that number is less than 6 for students who first searched Intrex, or less than 3 for students who first searched in the library.

feeling for the spectrum of components may be gained from Note 4 to Table B-4.

4. Retrieval effectiveness is calculated by adjusted useful references found per search-hour invested. The adjustment to the total number of useful references found excludes all references found only indirectly as the result of a formal catalog or index search process. Such secondary "hits" are a function of a specific document rather than a direct function of the indexing device. For example, these indirect hits include references found only through the bibliographies of directly retrieved documents. They also include multiple papers from the same conference volume if a direct search yielded only a citation to the complete proceedings rather than to the specific papers it contains; these sets of papers (what would constitute "analytics", had they been separately indexed) were counted as only one reference obtained by a direct and formal search. However, all indirect hits found as a result of a formal search have been included in the non-index search mode category. Thus, if the "adjusted total number of references used" in Table B-4 is greater than the "number of total references used", the difference is equal to the number of uncited volumes found by direct search which contained useful documents classified here as "indirectly found".

5. Three students divided their term paper bibliographies into two parts: references and additional readings. In two cases (A4, B2) the complete bibliography had been used in the text of the paper and all items were therefore counted. The third student (B5) only used actively the main reference list in his text and so only those references were counted; we note, regrettably for the measures of Intrex effectiveness, that his additional references, some 15 items, had all been retrieved through Intrex.

6. The data for experimental subjects A2 and B3, while shown in Table B-4, have been omitted from all summary calculations. The reliability of their stated library search times was determined to be highly suspect and including only their non-library data points would be a bias. In addition, student B3 did not have an analyst present during his Intrex searches.

7. The retrieval effectiveness averages reported in Table B-4 were calculated as the average of the ratios for each student. Not every student performed every kind of search mode and so the averages for any one parameter in the table are based only on the number of students for which data was available. Averages are reported separately for those who began their searches first with Intrex, first with the library or a non-index source, and for all students irrespective of their first search mode.

8. The students made considerable use of non-index sources of information. These sources include the class textbook, papers handed out or cited in class, personal libraries, personal communication with authorities or agencies in the field, browsing in the library stacks, and notably, browsing in the Professor's office through stacks of documents on the general area of the search topic. Because the time data for each of these kinds of searches was not sufficiently controlled, and does include occassional elements of document text reading, we have considered all of these sources together as a single non-index search mode. This mode also includes all indirectly found useful references no matter what mode of direct search retrieved the documents in which they are contained. While the data is thus biased toward a better comparative performance for the non-index search mode, the results do not affect comparisons between the Intrex and library index search modes, nor do we believe that overall comparative results would change significantly had there been better controls on the gathering of non-index search mode data. However, we would expect some components of the non-index mode to be more effective than other components of that mode.

Results of the Analysis. The overall retrieval effectiveness of Intrex is 1.8 adjusted useful references found per search hour. This is somewhat better than the 1.4 adjusted useful documents found per hour in the library search mode which included use of both the card catalog and abstracting and indexing services. For those students who started their search first with Intrex, the retrieval effectiveness for that group was 1.2 for the Intrex search mode and 1.1 for the library search mode. For those students who started their search first with the library, the retrieval effectiveness scores were 3.0 useful references found per hour for the Intrex search mode and 1.7 useful references per hour for the library search mode. A further examination of the retrieval effectiveness of the library index modes shows that the overall retrieval rate for the card catalog was markedly lower than the retrieval rate for other indexing sources in the library, 0.9 versus 1.7, respectively. The retrieval effectiveness of Intrex is comparable with that for the indexing services subscribed to by the library.

Thus, while searches in Intrex were more efficient than overall searching through catalogs and indices in the library, Intrex was not markedly more effective. This is attributed to the relatively small Intrex data base which we have estimated to contain less than 10 percent of the relevant documents on the three search topics which could be found in the library. Had Intrex coverage of these topics been as voluminous as that of the library sources, then the greater speed and ease of searching a unitary data base should have greatly increased the retrieval effectiveness of Intrex over that of the multi-volume library searches, a conclusion that each of the students readily endorsed.

At least some aspects of the non-index sources also show a commendable measure of speed and ease of access to information as evidenced by the fact that the retrieval effectiveness of the non-index search mode is markedly better than formalized searches through indices of any kind. The overall retrieval effectiveness of the non-index search mode was 4.5 useful references found per search hour. This figure is further broken down into the values of 4.6 and 4.3 useful references found per hour for the student group that began their first search with Intrex, and the group that began their first search with the library, respectively.

A more detailed and non-biased breakdown of the effectiveness figures for the non-index search mode is not possible from the data thus far collected. Nevertheless, it seems that formal information retrieval systems should be taking more advantage of non-formalized modes and undertaking steps to bring them into the formal information system. As but one example, an Intrex-like system can easily make personal files (libraries) available in much the same way as the formalized Intrex collection (see the section on the computer graphics data base in Section D on Inputting). The speed, ease, and results of searching through a file in a Professor's office can be made available to the larger audiences of the formalized system by incorporating such personally classified lists of documents into the system.

We observe in our data the suggestion of an "orientation to the subject" effect. Several students volunteered the information to the analysts that they were not familiar with the specific topics of the search prior to conducting the search. We note that students who began their Intrex search first had a retrieval effectiveness of 1.2 for Intrex searches which is considerably lower than the 3.9 value for all of their non-Intrex searches (library modes plus non-formal modes). For the group that did its Intrex searching last, their Intrex retrieval effectiveness was 3.0, a value better than the 2.7 effectiveness ratio obtained for all of their non-Intrex searches. We may hypothesize that the first mode of searching will be less effective than later search modes because searchers must first gain familiarity with the topic being searched and its organization in the literature. This suggestion of an orientation effect requires further investigation to fully substantiate it. In particular, the orientation effect might, in some cases, be expected to be reversed by a countereffect, namely that the last of several optimized search modes may be subject to the law of diminishing returns.

The group of students who did their Intrex searches last achieved a considerably higher retrieval effectiveness for both Intrex searches and library searches than did their counterparts in the group that began Intrex searches first. We believe this to be a statistical quirk due to a bias resulting from the small numbers of subjects involved. Specifically, the three students in the library search first mode were coincidentally more adept and/or more persistent in conducting searches in formalized sources.

The experimental data have also been reduced for each of the three search topics separately. Averages for each parameter calculated by giving equal weight to each search topic are very similar to the averages shown in Table B-4 and discussed above which give equal weight to the searchers. Averaging over equally-weighted search topics smoothes out the effects of individuals whose data points are at the extremes. The retrieval effectiveness ratios for equally weighted search topics are:

Adjusted Useful References Found per Search Hour	Averages for Students who First Searched Intrex	Averages for Students who First Searched the Library	Averages for All Students
Intrex Mode	1.2	3.0	1.7
Non-Intrex Modes	3.3-	2.7 -	3.1-
Library Index Modes	1.3	1.7 -	1.2-
Card Catalog Mode	1.3+	0.4	0.7+
Indexing Services Mode	1.3	2.0-	1.5
Non-Index Mode	3.7-	4.3 +	3.6-
All Modes	2.1-	2.8 -	2.3-

C. ECONOMIC ANALYSIS

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SUMMARY

The research related to the economics of information systems is proceeding along two interrelated directions. First, there is cost and service analysis. This subject involves the determination of the type and quantity of service required by potential users of information systems and an evaluation of the basic costs involved in providing such service. Secondly, there is the design of systems to most economically meet the needs of the user community. This topic includes the computer modeling of information systems and utilizes service and cost data to predict the economic feasibility of various designs as they relate to benefits reaped by users.

In relation to the first topic, data have been gathered on costs of computer hardware suitable for an information-retrieval system, costs of operation of the system, and costs of data communication. User service requirements have been estimated from our user experiments, reports dealing with population figures for science and engineering, and communication with other groups providing information-retrieval service.

In relation to the second topic, we have constructed some preliminary models for information systems. The models fall in two catogories — macroscopic models which deal with overall system characteristics, and microscopic models which deal in more detail with specific aspects of the information-service problem. Several useful results have been obtained in both areas.

An analysis has been made of data bases which are relevant to Intrex and available in machine-readable form. The analysis has been made from the viewpoints of their coverage overlaps and cost per item included on the tapes.

COST AND SERVICE ANALYSIS

The accumulation of cost and service data has continued during this reporting period. In addition to the basic costs for computer hardware, we have estimated costs for operation of the computer system. These operating costs include rental of floor space, utilities, supplies, and salaries of personnel. The operating costs and the costs for lease of equipment are two essential ingredients of the so-called fixed costs associated with providing information-retrieval (IR) service. A third ingredient of the fixed costs is the cost of data communications and terminals (if users do not provide their own). Communications costs are somewhat difficult to estimate because of the intimate dependence on the information-network configuration which in turn relates closely to the scientific population density and the demand for service in each area, and because of the many different types of service offered by the common carriers and the associated relatively complicated pricing schedule. Notwithstanding these, we have collected descriptive data on all of the types of communication service available and current cost information on most. By careful study of these data it is possible to draw some general conclusions on the best type of service and its cost for a network of which we know only the general characteristics. Some of these data have been used in conjunction with the modeling of information-service processes to compare alternatives in the design of a communication network.

In addition to the items discussed above, we have sent a list of questions related to user service and costs to an outside organization that provides interactive IR service on a fairly large scale. The answers should be of considerable utility.

Some thought and discussion has been devoted to estimating a user demand curve for information service, possibly as an experiment to be carried out in conjunction with our current user experiments. The demand curve would be useful in a number of applications including dynamic modeling of the entire information-service process (see next section). So far the difficulty in estimating a meaningful demand curve has precluded our implementation of it in our user experiments.

INFORMATION-SYSTEM MODELING

A new approach to economic analysis of IR systems has been intiated. This approach involves construction of a model of the system and simulating the model on a computer. The modeling approach is important for several reasons. First, it allows one to formally identify parameters of interest and importance that relate to cost and operation of the system and to place these parameters in proper perspective. Secondly, it permits one to simulate behavior of the system, that is, to evaluate performance for estimated resonable values of the parameters, and to study how the parameters interact, without actually building the system. Third, it permits one to evaluate the sensitivity of various quantities of interest to individual parameters and thus to identify parameters whose values are critical to effective operation of the system. Finally, modeling leads to the design of a better system and enables one to develop strategies for operating the system for optimality with respect to some measure of performance.

The models considered to date may be placed in two general catogories. The first type, macroscopic models, deals with the overall characteristics of information systems. The second type, microscopic models, deals in a more detailed manner with specific aspects of IR systems, usually to obtain results which can be incorporated into the macroscopic models. Models in each of these catogories are discussed separately below.

Macroscopic Modeling. As a first step in modeling IR systems, a simple model was developed that deals with the overall characteristics of a system serving a heterogeneous community of users. This model, although relatively simple, is considerably more detailed and comprehensive than ad hoc estimates with typical numbers which have been our best means of analysis up to now. For example, the model takes into account the nonlinear form of the relation between revenue obtained for information service supplied. Two forms of the function representing this relation are shown in Fig. IIC-1. The total time T that the system is made available for service each

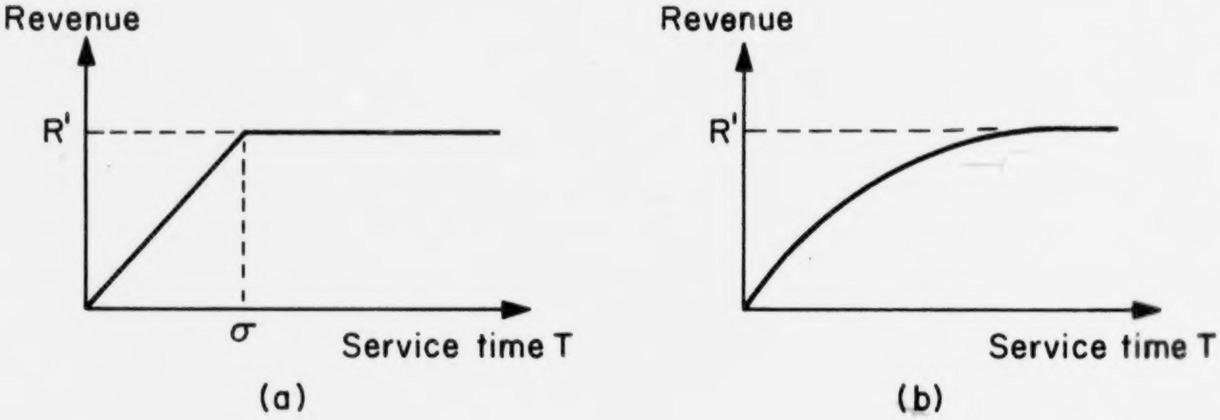

Fig. IIC-1 Gross Revenue as a Function of Service Time for an IR System

month is plotted on the horizontal axis, and the average total revenue is plotted on the vertical axis. Fig. IIC-1a represents the case where users arrange to use all the available time by "signing up" for use of a console. There is a point $T = \sigma$ at which the number of terminal hours of service provided exactly matches the service required by the user community. If more service than this is provided, it will not be consumed and no additional revenue will be generated. Thus the function is flat for T greater than σ. If less service is provided, it will all be consumed and revenue will be directly proportional to the hours of service provided.

Fig. IIC-1b represents the case where the user community requires the same amount of service, but users arrive at random at the consoles. Here the revenue is seen to follow a law of "diminishing returns". For small amounts of service provided (compared to user requirements), revenue is approximately proportional to service. For larger amounts of service the increase in revenue becomes less for each increase in service time and asymptotically approaches the maximum possible revenue R'. Both types of revenue functions are found to be of use in the model.

The complete system model is depicted in Fig. IIC-2. Parameters related to cost and user-service data are supplied as input. Output quantities are net profit and the service index. The latter quantity is a number between 0 and 1 and indicates the extent to which the service needs of the user community are met. A service index of 1 indicates that all users are, on the average, able to obtain their required amount of service; a service index of less than 1 indicates that only some fraction of the required service is being provided. Thus a service index of 0.75 means that, on the average, 75% of the service required by the user community is being supplied to it.

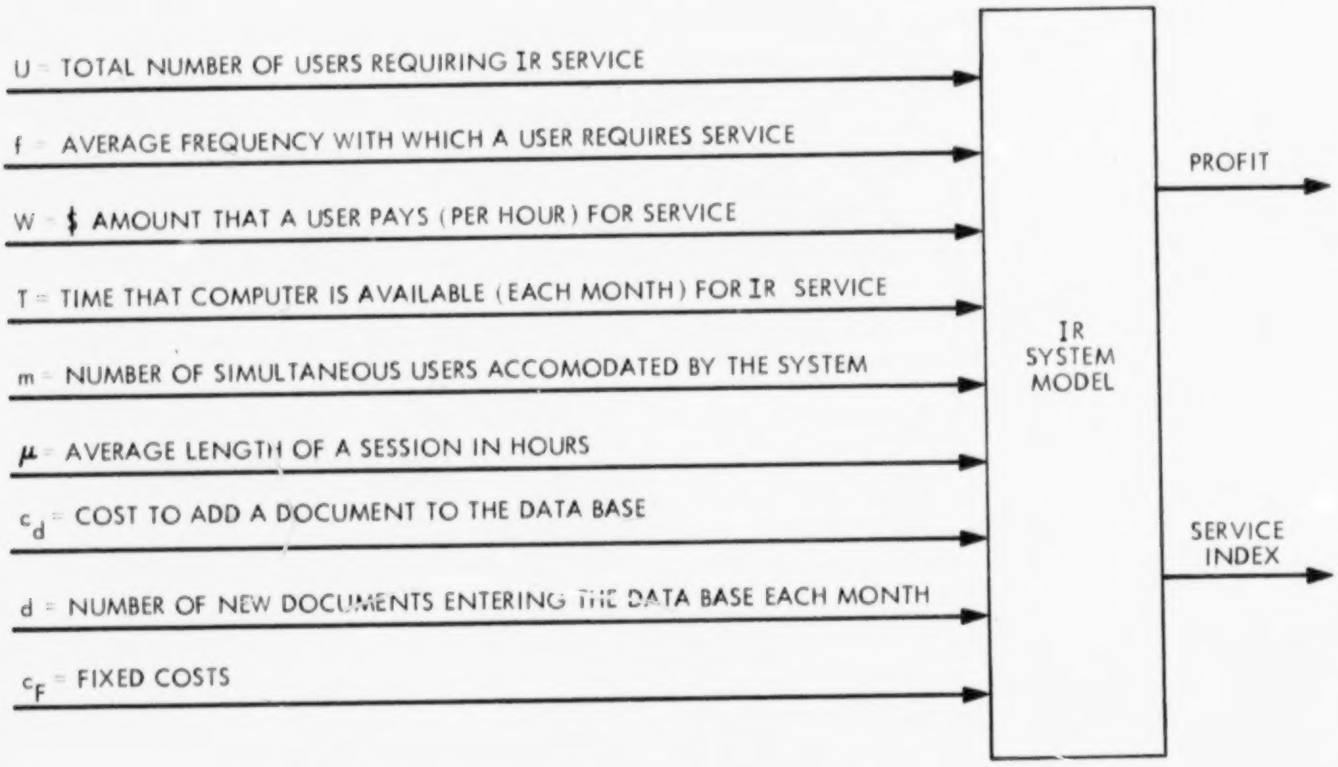
U = TOTAL NUMBER OF USERS REQUIRING IR SERVICE
f = AVERAGE FREQUENCY WITH WHICH A USER REQUIRES SERVICE
W = $ AMOUNT THAT A USER PAYS (PER HOUR) FOR SERVICE
T = TIME THAT COMPUTER IS AVAILABLE (EACH MONTH) FOR IR SERVICE
m = NUMBER OF SIMULTANEOUS USERS ACCOMODATED BY THE SYSTEM
μ = AVERAGE LENGTH OF A SESSION IN HOURS
c_d = COST TO ADD A DOCUMENT TO THE DATA BASE
d = NUMBER OF NEW DOCUMENTS ENTERING THE DATA BASE EACH MONTH
c_F = FIXED COSTS
IR SYSTEM MODEL
PROFIT
SERVICE INDEX

Fig. IIC-2 Simple IR System Model

One of the advantages of formal modeling of systems, as indicated above, is that one can study the relation between two or more system parameters. For example, it was found that when the number of new documents being replaced in the data base each month is large, the cost incurred for each document entering the data base strongly influences the price that users must be charged in order to break even. As a further illustration, consider a center serving 12,000 users with a document turnover of 20,000 documents per month[*] and a service requirement of two sessions per month per user, each session lasting approximately one-half hour. The fixed costs for a system capable of serving this community are $47,000 per month. In addition, if half of these users are at distances remote from the center, say distributed evenly across the country, data communications could add as much as $58,000 to the fixed costs. The cost per document added to the data base is not known exactly. However this cost in a more automated operation is almost certainly less than our present Intrex cost of $10 per document and probably more than $1 per document. With these data, the hourly cost to a user predicted by the model for break-even operation falls within the top shaded area of Fig. IIC-3. The solid line which is the lower boundary of that area is

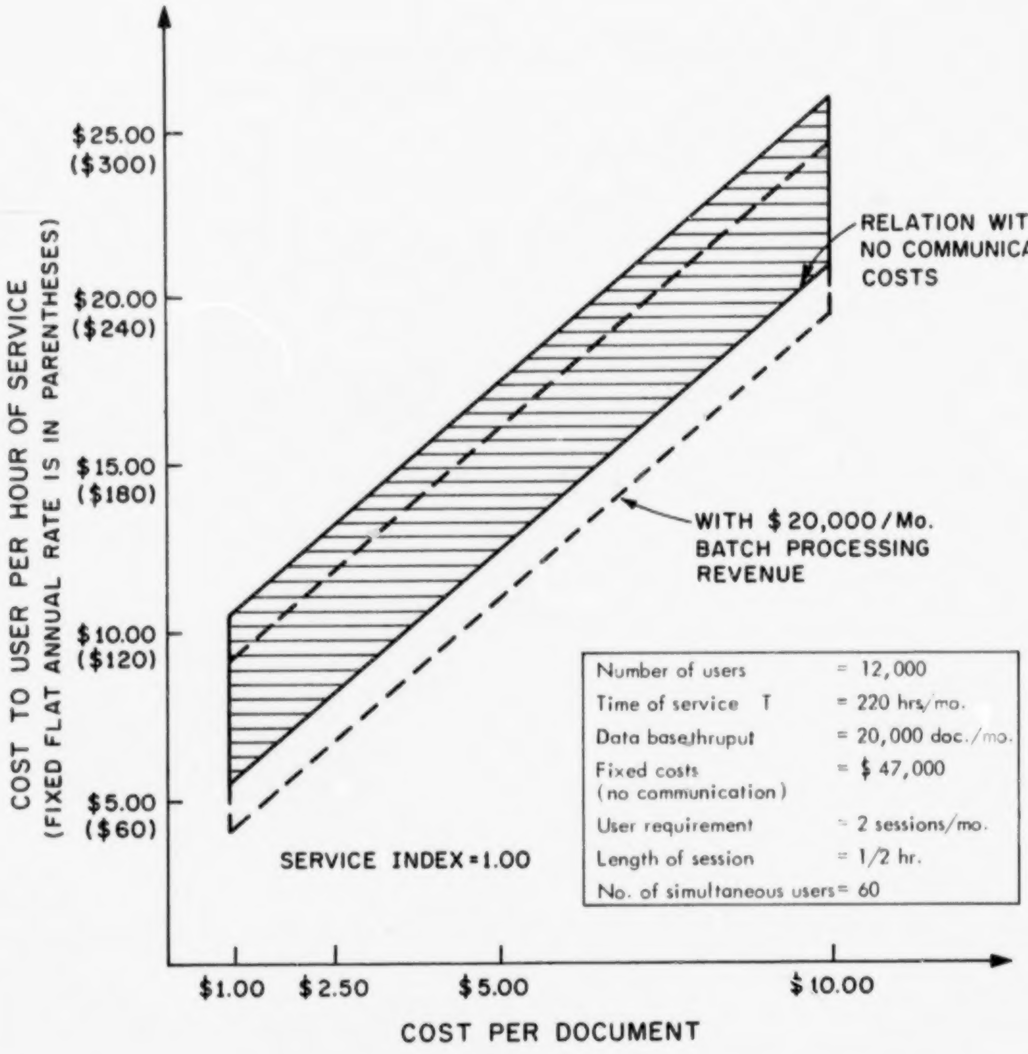

Fig. IIC-3 Cost to user versus cost per document under "break-even" conditions.

---

[*] This is the rate that must be maintained for a data base of one million documents covering the latest four years of publications.

the relation between cost to users and cost per document when communications costs are not incurred by the system. The top area is in one sense an upper bound on the cost to users since it does not take into account additional revenue that could be brought in by using the computer for batch-processing operations during times when on-line service is not demanding the full attention of the computer. If batch operation were to net \$20,000 per month, the area in Fig. IIC-3 representing cost to on-line users would be moved down, as shown by the dotted lines. Several similar parametric studies have been carried out for various values of user-service requirements.

The model of Fig. IIC-2 can form the basis for a more advanced dynamic model in which parameters heretofore assumed independent interact, and outputs of the system feed back to influence inputs. Such a dynamic model is depicted in Fig. IIC-4.

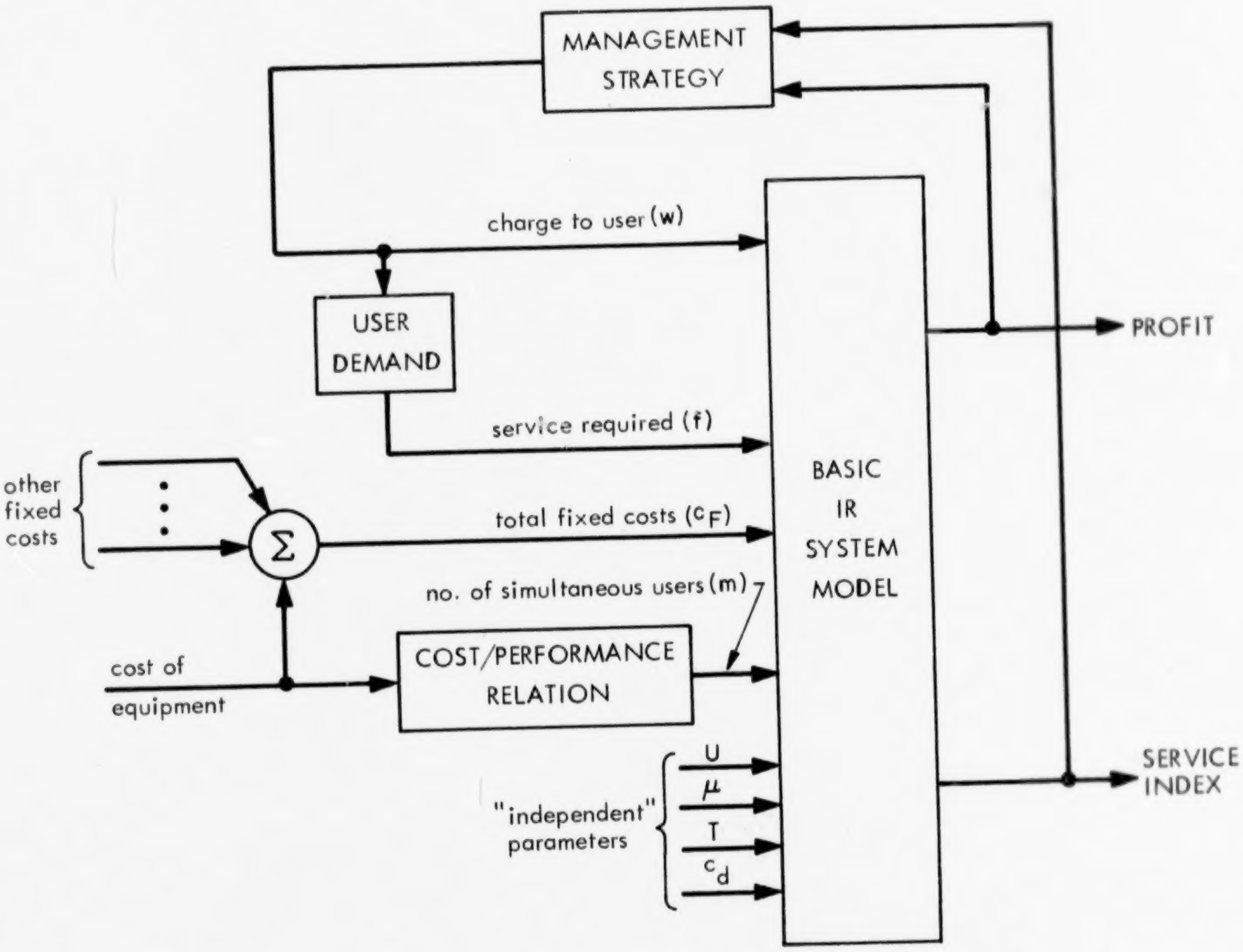
MANAGEMENT STRATEGY
charge to user (w)
USER DEMAND
PROFIT
service required (f)
other fixed costs
Σ
total fixed costs (c_F)
BASIC IR SYSTEM MODEL
no. of simultaneous users (m)
cost of equipment
COST/PERFORMANCE RELATION
"independent" parameters
U
μ
T
c_d
SERVICE INDEX

Fig. IIC-4 Dynamic Model for an IR System

Here the user demand for information services is related to the price of service through the user demand curve. The price of service is set by management and is based on system performance in the preceding time period. Cost of equipment determines system capacity and other parameters are assumed independent. This model has been simulated on the computer using a reasonably estimated user demand curve and a management strategy based on the profit alone. It was possible to identify regions of stable, semistable, and unstable operation for several different sets of parameters. The results, however, have not yet been documented.

Microscopic Modeling. In the area of microscopic models, two topics have been considered. The first deals with the problem of providing multiple data bases at a single IR center and leads to an algorithm for optimally scheduling these data bases. The second topic deals with stochastically modeling the IR system service process. The arrival of users is assumed to be characterized by a Poisson distribution and the service system is represented by a Markov Chain with exponential holding times. The revenue function of Fig. IIC-1b was derived from this model. The same model was used to investigate cost/benefit relations for a nationwide telecommunication network terminating in a single IR center. For such an application the WATS leased-line service of the Bell system is the most economical. WATS lines permit unlimited calling to the center for a fixed monthly charge provided the call is made from within the "WATS area". There are six WATS areas and these are roughly concentric circles with centers at the point to be called (see Fig. IIC-5). Assuming that users are distributed evenly among the six

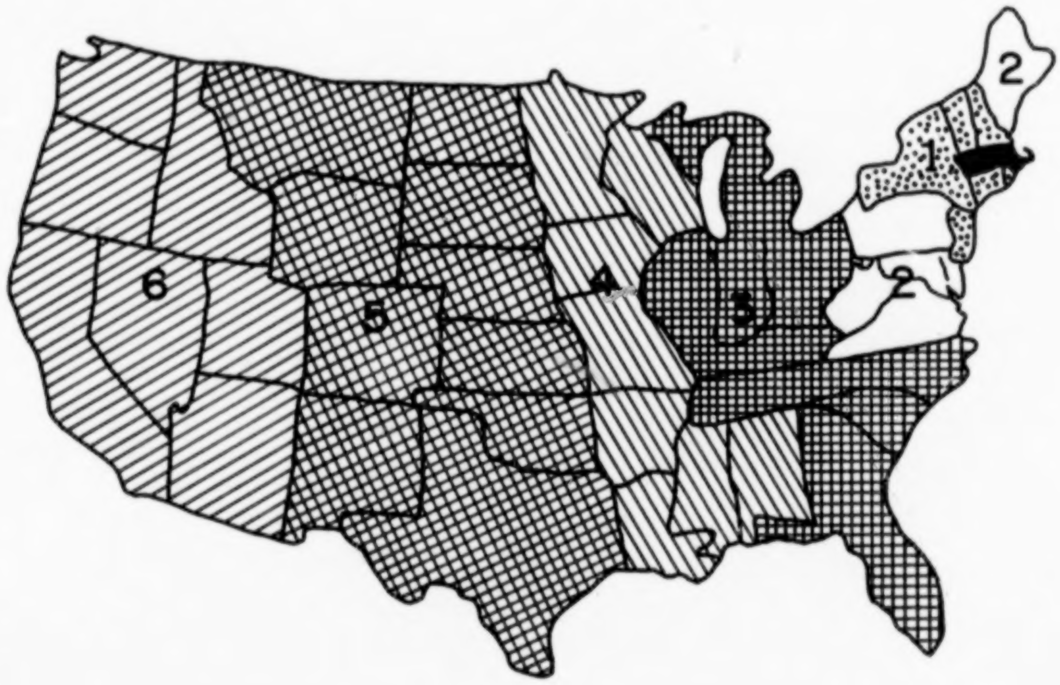

Fig. IIC-5 WATS Areas Relative to Massachusetts

WATS areas and that there are m ports into the computer, one has the choice of providing m full-coverage (that is, Area 6) WATS lines on which all users may call, or dedicating m/6 lines to users in each of the WATS areas and so taking advantage of reduced costs. The m full-coverage lines will obviously provide better service to users, but what are the trade-offs? Here is what the results of modeling this situation show.

For typical values of user-service requirements, the full coverage lines indeed provide the best service. One set of data showed the probability of a busy line to be about 10%. For the same set of data the chance of a busy line with dedicated groups of lines is about 25%, or one time in four. The cost of the dedicated lines is considerably lower but the loss of revenue due to poorer service is greater than the savings in cost — a fact which might have been overlooked. The best choice is clearly the full-coverage lines. A third alternative is to provide a number of lines greater than m/6 to each area in order to achieve the same low probability of a busy line yielded by the m full-coverage lines. The cost of this alternative is surprisingly close to the cost of the m full-coverage lines for several cases tried, suggesting that perhaps Bell used a similar model to set up their rate schedule!

COVERAGE OVERLAP AND COST ANALYSIS OF BIBLIOGRAPHIC SERVICES

Future large-scale, computer-based bibliographic information storage and retrieval systems may need, especially in their formative stages, to take advantage of externally generated, machine-readable data bases. Integrating a large number of such data bases, each with different data types and data formats, into a unifying system configuration poses considerable problems on both the technical-system level and the user-interface level. The development and use of communications formats for data transfer and other related standards are important steps in solving such problems. Another problem of large-scale bibliographic integration concerns the mode in which a system makes these data bases available. At the two extremes, we can have one very large merged data base, or a series of smaller separated data bases each corresponding to the service which generated it. A number of other possibilities fall in between these two extremes which include combining only a few services, and/or using selected portionsof services. These questions of the data-base coverage configuration depend upon technical and economic considerations plus considerations of data base mixes appropriate to the user clientele. This latter point raises questions about the uniqueness, timeliness, and overlap in coverage of available services.

Overlap by Journal Articles Covered. A preliminary study of coverage overlap was made among Intrex and several tape services of interest to the thrust of the current Intrex data base. This study considered overlap only on the basis of journal titles, and not of individual articles selected from journals covered by Intrex or by a service. The data were reduced to a series of bar graphs, one for each service, showing the percentages of journal titles covered by that service which are covered completely or selectively by other services. One of these graphs is reproduced in Fig. IIC-6, showing the coverage given by other services to the 71 journal titles covered selectively by Intrex. A study of the full set of graphs shows that considerable care must be given to the basis for comparision. For example, the overlap percentage between services for a set of journal titles indexed completely by one service is different from the percentage overlap for a set of journal titles indexed only selectively by a service.

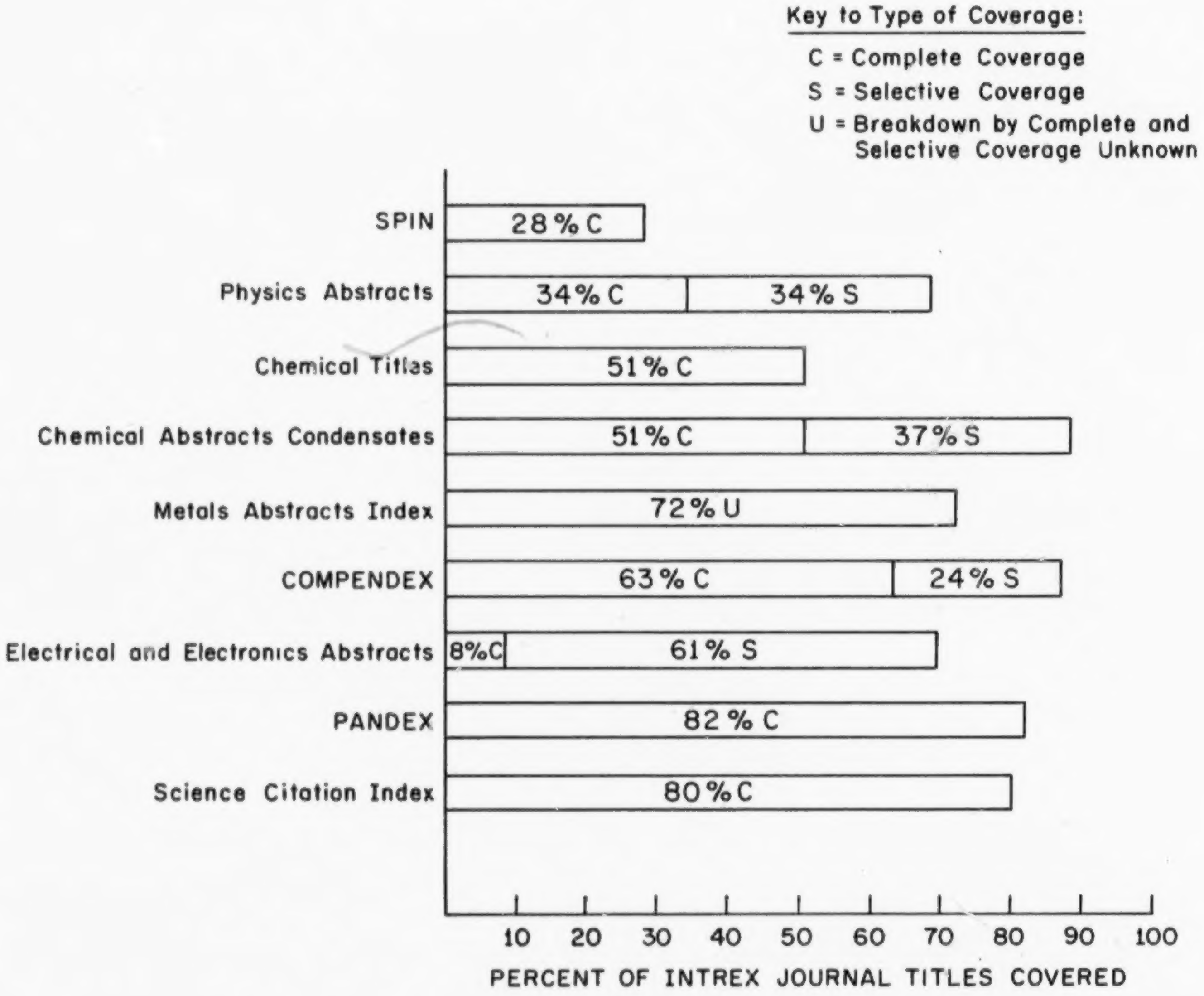

Fig. IIC-6 Percentage of type of coverage by other services of the 71 journal titles covered selectively by the Intrex data base.

Overlap by Journal Articles Covered. The majority of large abstracting and indexing services do cover-to-cover indexing of articles for only 10% to 15% of the source journal titles that they cover, although the articles from the smaller set of titles may provide more than half of the total individual records in the service. The most meaningful results of coverage overlap can be obtained only when overlap between services for individual articles is studied. This point was addressed in a second study comparing journal-article overlap between Physics Abstracts and Metals Abstracts. A systematic sampling of articles from the 1969 volumes of the two services shows that of all Physics Abstracts articles, 10 percent were covered by Metals Abstracts (but not necessarily in 1969), 60 percent were from Metals Abstracts source journals but did not appear in Metals Abstracts through 1970, and 30 percent were from journals not reviewed by Metals Abstracts. Of all Metals Abstracts articles sampled, some 28 percent appeared in Physics Abstracts (but not necessarily in 1969), 12 percent were from Physics Abstracts source journals but did not appear in Physics Abstracts through 1970, and the remaining 60 percent were from journals not reviewed by Physics Abstracts. These data are significantly different from those provided by the study of journal-title overlap, where 62 percent of journal titles completely covered by Physics Abstracts are covered (completely or selectively) by Metals Abstracts, and 7 percent of all titles covered by Metals Abstracts are titles completely covered by Physics Abstracts. Article overlap between services also varies significantly with the classed subject sections into which articles are grouped in each service.

A Model for Journal Article Overlap. A model to predict article overlap between two abstracting services was developed. A best-estimate is made of the extent of subject interest in each classed section of one service by the other service. The percentage of maximum subject cross interest between services is derived by weighting the estimated interest in each section by the actual relative percentage contribution of the section to the total service. A correction for disparities in the sizes of the two services is made by weighting the results for the larger service by the ratio of the number of abstracts published by the smaller service to that published by the larger service. Thus, the percent of 1969 Physics Abstract articles also covered by Metals Abstracts is predicted by the model to be 19.5% while the sample data show a 10% overlap. The percent of Metals Abstracts articles also covered by Physics Abstracts is predicted by the model to be 32%, whereas the sample data show a 28% overlap. For 1970, the predicted percentage of Physics Abstracts articles in Metals Abstracts decreases to 12% because of a 60% increase in the size of the Physics Abstracts data base. The model may be considered to predict maximum percentages of overlap that are more realistic than overlap percentages calculated only on the basis of journal titles covered. The only assumption made in the model is a best-guess of mutual subject interests in each classed section of a service. The general applicability of the model to predict overlap among other services has not been tested.

Cost Analysis. Costs of some 33 tape services or parts of services as a function of their data-base size were investigated. The initial data came primarily from an American Institute of Physics report,* although more recent data were used when available. Control for the number of characters and/or intellectual data content of the document records in a service was roughly made by characterizing the service as:

Type A: Provides an abstract in addition to the basic citation, but without taking into consideration the extent or depth of indexing provided. (Most of the services in this group offered some form of enriched indexing beyond title words.)

Type E: Provides the basic citation, plus enriched indexing of any kind or depth beyond that of title words, but no abstract is given.

Type B: Provides only the basic citation with no indexing or no indexing beyond title keyword, and no abstract.

Type C: Provides the basic citation plus extended data other than that of abstract or index terms, e.g., reference citations.

The results for each group are shown in Fig. IIC-7. The names of the services corresponding to the numbered data points are listed in Table C-1. The data points suggest an expected inverse or hyperbolic relationship between items/year and cost/item, but the spread of these points and the lack of any clear distinctions between the types of services is unexpected. The point spread is particularly evident for the "smaller" services (less than 75, 000 items/year). A clearer pattern along the lines anticipated of higher unit costs for tapes with bigger records or records with more intellectual content, was more often evident when comparing different forms of a particular service. Some critical factor of organization size or discipline size may be at work in terms of efficient service operation and/or the available sales market. Then, too, the pricing structure of some tape services may partially support other disseminative publications of the organization.

---

* "Survey of Scientific-Technical Tape Services", compiled and edited by Kenneth D. Carroll, American Institute of Physics, September 1970, AIP ID 70-3.

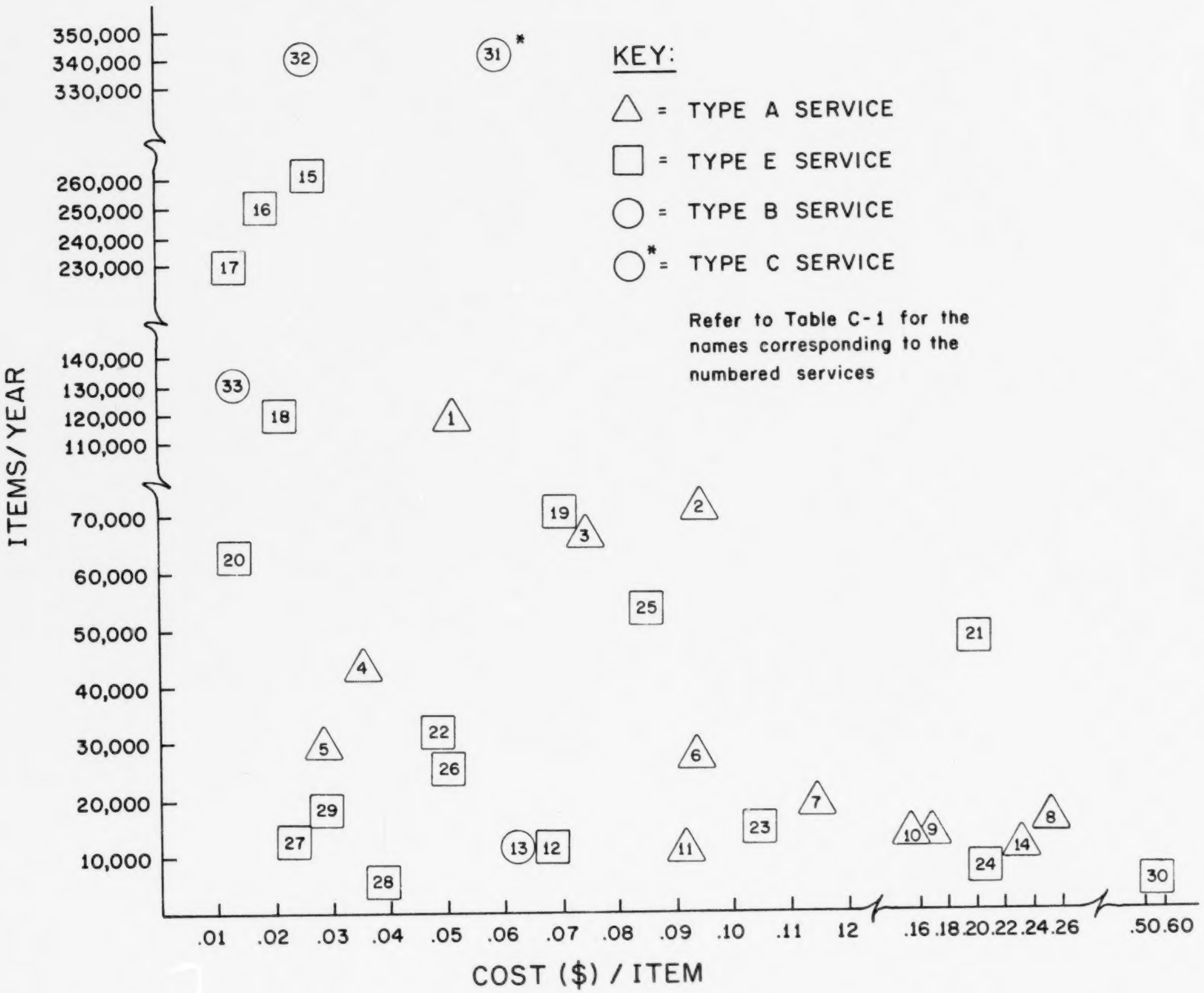

Fig. IIC-7 Tape-Service Data-Base Size vs. Unit Document Surrogate Cost

Table C-1

List of Tape Services for which Data on Unit Document Surrogate Cost versus Service Size are Presented in Fig. IIC-7

	SERVICE	TYPE
1.	INSPEC (total service)	A
2.	COMPENDEX	A
3.	IEEE REFLECS (ceased publication)	A
4.	US Government Research and Development Reports	A
5.	ERIC	A
6.	SPIN	A
7.	Chemical-Biological Activities (CBAC)	A
8.	Basic Journal Abstracts	A
9.	Polymer Science and Technology - Journals (Post-J)	A
10.	Polymer Science and Technology - Patents (Post-P)	A
11.	Institute of Paper Chemistry - Abstract Bulletin	A
12.	Institute of Paper Chemistry - Keyword Supplement	E
13.	Institute of Paper Chemistry - Citation Tape for Abstract Bulletin	B
14.	Services 11, 12, 13 Combined	A
15.	PANDEX	E
16.	CA - Condensates	E
17.	BA Previews	E
18.	AGRIDEX	E
19.	Uniterm Index to U.S. Chemical and Chemically-Related Patents	E
20.	MARC	E
21.	Index Chemicus Registry System (ICRS)	E
22.	Current Index to Conference Papers in Engineering	E
23.	Current Index to Conference Papers in Life Sciences	E
24.	Current Index to Conference Papers in Chemistry	E
25.	Services 22, 23, 24 Combined	E
26.	Metals Abstracts Index	E
27.	CITE - Electrical/Electronics	E
28.	CITE - Plastics	E
29.	Services 27 and 28, Combined	E
30.	Virology Index	E
31.	Institute for Scientific Information Combined Source and Citation Data	C
32.	Institute for Scientific Information Source Data Alone	B
33.	Chemical Titles	B

D. AUGMENTED-CATALOG INPUTTING

Staff Members

Miss M.A. Jackson
Miss L.T. Lee
Miss V.A. Miethe

Cataloger Assistants

Miss M.A. Flaherty
Miss L.A. Langille

Undergraduate Students

Mr. L.E. Bergmann
Mr. D.W. Buckley
Mr. M.S. Fuller
Mr. D.B. Krasnick
Mr. P.L. Martin
Mr. F. Spahn
Mr. J.R. Ward

SUMMARY

A personal file of an M.I.T. Faculty member, consisting of a collection of 182 documents in the area of computer graphics has been added to the data base. The format of these catalog records and several unique applications of the catalog structure and retrieval system are discussed.

The correction loop has been revised to create a smoother work flow and to shorten elapsed time between keying and final loading into the data base. On-line keying of catalog record data has been implemented with little difficulty and the effects of the anticipated problems have been minimized. The Flexowriter model used for off-line paper tape input has been changed. A new distribution of costs for keying and preparation of paper tapes is outlined.

A tabulation of processing performance characteristics of documents primarily input on-line is presented and compared with those previously reported. Feedback from work with users in the open environment has indicated that more attention should be given to explanations of the data-base coverage and the functional role of catalog data elements. As a first step in studying these roles, a categorization of catalog data fields by function was prepared and incorporated into the instructional aids. Also, an improved listing of subject areas covered in the Intrex data base has been prepared.

Preliminary results of an analysis of the subject indexing and descriptive cataloging review process are reported. A comparison of the number, major contributory cause, and field distribution of errors in files input on-line and off-line is summarized.

As of 1 September 1971, 18,700 documents were indexed, 17,870 records have completed the correction loop and 15,850 records were completely processed into the computer-stored data base.

COMPUTER-GRAPHICS DATA BASE

As a means of testing the flexibility and hospitability of the Intrex augmented-catalog structure to diverse document types and to experiment with the addition of personal files to the Intrex data base, a collection of 182 documents in the subject area of computer-graphics has been added to the data base. The documents were originally gathered and cataloged for a personal file by Michael W. Dickens, a graduate student working on his Master's thesis* under Professor M.L. Dertouzos. The catalog data prepared by Mr. Dickens were accepted with minimal modification and integrated into the Intrex structure. A sample catalog record is shown in Fig. IID-1. Several unique applications of the catalog structure and retrieval system were made with the computer-graphics data base. These applications are described below in terms of the relevant Intrex catalog fields and in terms of the subject-classification scheme developed by Mr. Dickens for the computer-graphics area. In catalog field-number order, they are:

> Field 1 - Document Number: The computer-graphics project was assigned a block of 1,000 numbers (25000-25999) so that additions could be made to the collection at any time. In addition, the collection would be easily distinguished from the regular Intrex data base through an approach independent of subject indexing.
>
> Field 5 - Fiche: No microfiche copy (text-access) is available for any of these documents.
>
> Field 22 - Affiliation: Only the affiliation for the first author was provided.
>
> Fields 67, 68, 69 - Table of Contents, Special Features, Bibliography: These fields are not used for this collection as such; however, elements of these items have been included in Fields 71 and 73 - see discussion below.
>
> Field 71 - Abstract: An abstract was written by Mr. Dickens for each article in a telegraphic, semi-outline form. It was expanded slightly for readability and adopted in place of the standard author abstract.
>
> Field 73 - Subjects: The subject phrases were generated by Mr. Dickens after brief instruction from an Intrex cataloger. These phrases are, in general, much shorter and lack the depth of Intrex indexing. These phrases can be more closely allied to key words than to Intrex-like in-depth subject phrases. See below for the special usages given to range (0) and range (4) terms.
>
> Field 85 - User Comments: Mr. Dickens had included comments about some of the articles in his file and these were included in field 85. These comments tend to be of a short, critical nature which illuminate aspects of the text that are not apparent from the abstract.

The other fields of the catalog record required no change from regular Intrex usage.

---

* Dickens, Michael W., Computer Graphics: Central Problems and Their Treatment. M.I.T., Cambridge, Mass. Dept. of Electrical Engineering, June, 1971.

```
1. DOCUMENT 25485
 CHOSEN                              (FIELD 2)
  Hybrid computing structures (Professor Dertouzos); Graduate student
 CATALOGER                           (FIELD 3)
  6100
 ONLINE                              (FIELD 4)
  04/27/71
 MAIN                                (FIELD 20)
  Personal author
 AUTHOR                              (FIELD 21)
  Hornbuckle, Gary D.
 AFFILIATION                         (FIELD 22)
  University of California, Berkeley.
 TITLE                               (FIELD 24)
  The computer graphics user/machine interface
 MEDIUM                              (FIELD 30)
  Conventional
 FORMAT                              (FIELD 31)
  Professional journal article
 LANGUAGE                            (FIELD 36)
  English
 ABLANG                              (FIELD 37)
  English
 LOCATION                            (FIELD 47)
  IEHFA. v.HFE-8, no.1,030067. pp.17-20.
 PURPOSE                             (FIELD 65)
  Essay
 APPROACH                            (FIELD 66)
  Professional
 ABSTRACT                            (FIELD 71)
  interface with real-time sequenced pattern recognition / graphics to
    improve class of editors, debuggers;
   1. Introduction - ingredient in design - pattern recognition;
   2. stroke classification;
   3. stroke content recognition;
   4. equipment - RAND or mouse;
   5. applications - text editing;
   6. graphical debugging;
   7. conclusions - pattern recognition could improve interface (M.W.D.)
 SUBJECTS                            (FIELD 73)
  classification - cga0, cga2, cgh0, cgh3, cgh31 (0);
  computer graphics system interface with character recognition from A.I.
    related area (0);
  user machine interface with pattern recognition (1);
  referenced documents - 25320, 25204, 25122, 25270 (4);

 COMMENTS                            (FIELD 85)
  paper shows how to do it - nothing implemented - pattern recognition
    more than Computer Graphics (M.W. Dickens; 37-415.)
 FICHE                               (FIELD 5)
    Hard copy is found at library with code name  e .  See Part 15.11 of
    the Guide for explanation of code.
```

Fig. IID-1 A Sample Computer-Graphics Catalog Record

The subject retrieval of these documents has been enhanced by a hierarchical classification scheme which had been devised by Mr. Dickens for the computer-graphics literature (see Fig. IID-2 showing the scheme with its alphanumeric class numbers). He had assigned the most relevant classification number to each document. To circumvent the present lack of user-specified prefix search facility in Intrex, all generic terms of the hierarchical tree have been added to the subject terms for each classification assigned by Mr. Dickens. In this way, a search on any classification term will retrieve all documents classified under that term. For example, an article classified cgb212 (refresh features of CRT's) can also be considered as included in the more generics cgb21, cgb2 and cgb0 and therefore will be retrieved in a search for any of those classification numbers.

The assigned classification numbers are coordinated into a single index term which is assigned an Intrex range-number zero. That range number is normally assigned to generic terms. An example of a computer-graphics zero-range term is:

classification - cga0, cga1, cga12, cgg0, cgf0, cgf1 (0);

The word "classification" gives Intrex users outside the computer-graphics group some indication of the intent of the numbers in the remainder of the term. The letters "cg" were added by Intrex to create a unique searching string.

A verbal translation of these classification numbers was provided by adding another zero-range subject term which includes the phrase "computer graphics". This term allows verbal as well as alphanumeric access to the computer-graphics classification scheme and, in particular, enables the compilation of a complete bibliography of computer-graphics by the search-command line: "subject computer graphics".

A list of other documents within the same computer-graphics collection which were referenced by the document at hand was incorporated into a range four subject term in the form:

referenced documents -25143, 25101, 25158, 25006 (4);

Range 4 is normally assigned to tools and materials used in the reported work. The inverted subject file can now provide a "citation" search capability for this collection, that is, a list of documents which reference the given document. Also included in a range 4 subject term are notes such as "referenced documents on color", "referenced documents on geometry". These phrases indicate that the references found in the document were not about computer-graphics as such, but are more properly classified under the subject mentioned (here, "color" or "geometry").

In summary, the basic structure of the Intrex catalog proved to be flexible and hospitable to the addition of this personal file. Only minor modifications to the original data were required in order to incorporate the unique features of this bibliographic data set within the current retrieval system.

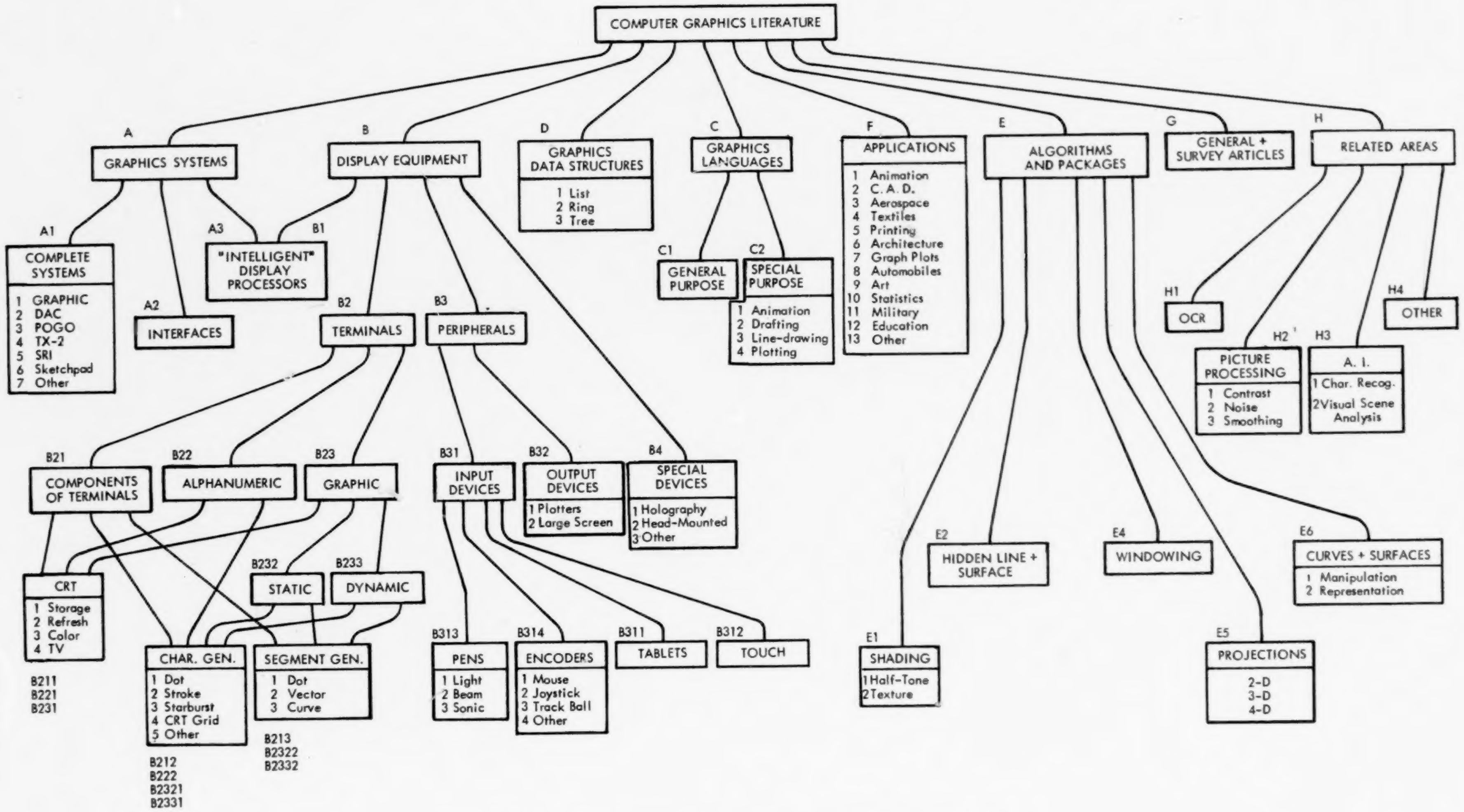
COMPUTER GRAPHICS LITERATURE
A
GRAPHICS SYSTEMS
B
DISPLAY EQUIPMENT
D
GRAPHICS DATA STRUCTURES
1 List
2 Ring
3 Tree
C
GRAPHICS LANGUAGES
F
APPLICATIONS
1 Animation
2 C. A. D.
3 Aerospace
4 Textiles
5 Printing
6 Architecture
7 Graph Plots
8 Automobiles
9 Art
10 Statistics
11 Military
12 Education
13 Other
E
ALGORITHMS AND PACKAGES
G
GENERAL + SURVEY ARTICLES
H
RELATED AREAS
A1
COMPLETE SYSTEMS
1 GRAPHIC
2 DAC
3 POGO
4 TX-2
5 SRI
6 Sketchpad
7 Other
A2
INTERFACES
A3
B1
"INTELLIGENT" DISPLAY PROCESSORS
B2
TERMINALS
B3
PERIPHERALS
C1
GENERAL PURPOSE
C2
SPECIAL PURPOSE
1 Animation
2 Drafting
3 Line-drawing
4 Plotting
H1
OCR
H2
PICTURE PROCESSING
1 Contrast
2 Noise
3 Smoothing
H3
A. I.
1 Char. Recog.
2 Visual Scene Analysis
H4
OTHER
B21
COMPONENTS OF TERMINALS
B22
ALPHANUMERIC
B23
GRAPHIC
B31
INPUT DEVICES
B32
OUTPUT DEVICES
1 Plotters
2 Large Screen
B4
SPECIAL DEVICES
1 Holography
2 Head-Mounted
3 Other
E2
HIDDEN LINE + SURFACE
E4
WINDOWING
E6
CURVES + SURFACES
1 Manipulation
2 Representation
CRT
1 Storage
2 Refresh
3 Color
4 TV
B211
B221
B231
B232
STATIC
B233
DYNAMIC
CHAR. GEN.
1 Dot
2 Stroke
3 Starburst
4 CRT Grid
5 Other
B212
B222
B2321
B2331
SEGMENT GEN.
1 Dot
2 Vector
3 Curve
B213
B2322
B2332
B313
PENS
1 Light
2 Beam
3 Sonic
B314
ENCODERS
1 Mouse
2 Joystick
3 Track Ball
4 Other
B311
TABLETS
B312
TOUCH
E1
SHADING
1 Half-Tone
2 Texture
E5
PROJECTIONS
2-D
3-D
4-D

Fig. IID-2 The Computer Graphics Classification Scheme Devised by Michael W. Dickens

PROCESSING OF REGULAR INTREX DOCUMENTS

General. The correction loop has been revised to create a smoother work flow and to shorten the time from keying through final loading of the records into the regular Intrex data base. Previously, printouts for manual proofreading were requested at the end of each month for all files typed during that month. The files were proofread and edited during the following month for the next monthly update of the data base with corrected files.

As a result of on-line keyboarding of most new files, printouts for manual proofreading are now requested as soon as the file has been completely keyed. The printouts are available the next morning. First manual proofreading is now done by catalogers at a rate of two files per day, creating a slow but continual flow of editing to the typists. If the printout backlog increases, the rate of first proofreading is increased to a maximum of three files per day. Data-base updates are now optimally planned when approximately 50 files have completed the correction loop.

As of June 1, 1971 the data base consisted of 15,850 documents, a number sufficient to maintain the experimental program scheduled for the summer months. Therefore, in light of the natural decrease in system usage over the summer months and the costs of updating and maintaining the enlarged data base, the addition of new documents to the data base was postponed for the summer. However, the normal correction-loop cycle preceding the update was continued. As documents completed the correction-loop processing, they were written onto magnetic tape and stored for later update.

As of 1 September 1971:

18,700	documents were indexed
18,650	catalog records were reviewed
18,300	records were keyed
17,870	records have completed the correction loop
15,850	records were completely processed into the computer-stored data base

On-Line Input. On-line keying of catalog-record data, discussed in the 15 March 1971 Semiannual Activity Report, has proceeded without difficulty during its first six months of operation. During that time 86% of all files keyed were done on-line.

The production problems anticipated from the effects of computer down time have been gradually minimized. The schedule of preventive maintenance sessions on the computer, which originally consumed approximately 1 1/2 working hours per week, was changed by arrangement with the Information Processing Center so that production is now interrupted for that purpose only two hours per month.

Unscheduled down time poses a greater obstacle. For the period March 1 through July 30, 1971, the computer was down approximately 11% of available working hours, or about 3 3/4 hours per week. During this down time, the paper-tape backup facility was utilized. As the months progressed, this down time was used more for record keeping and other clerical duties associated with the keying process. Use of the paper-tape back-up facility was decreased so that computer up-time could be fully utilized for input. Reliance on the back-up facility decreased from a high of 20% of keying output versus only 10% computer down time in March to a low of 6% keying output versus 12% down time in July without any noticeable decrease in input rate.

Flexowriter Model Change and Paper-Tape Input Costs. The successful changeover to on-line input with minimal down time, greatly diminished the requirement for reliable off-line punched paper-tape input equipment. Continuation of the rental of punched paper tape equipment which would be idle more than 90% of the time became uneconomical. Therefore, in June, the rental contracts on the Model 2303 Friden Flexowriters were cancelled. Two older model TX-O Flexowriters, already owned by M.I.T., were transferred to Intrex for use as input back-up equipment.

The substitution involved changing some special character keys on these machines. In addition, tables for conversion of Flexowriter code to ASCII code, used in the print program, were revised by the software group. It was necessary for the typists to learn the new punch code which initially slowed the keying rate somewhat, but this problem has easily been resolved through experience.

Costs for paper-tape input of catalog records were analyzed in a study in 1968 and were later updated to 1970 values (see 15 September 1968 and 15 March 1971 Semiannual Activity Reports). The breakdown of costs per file of ten documents, as reported last March, is:

Keying Operator Time	$18.45
Computer Processing Time	1.32
Computer Operator Time	0.46
Flexowriter Rental	2.72
Materials (Paper Tape)	0.70
TOTAL (10 Documents)	$23.65

With the recent change in Flexowriter models, rental costs can be excluded in the calculation of the actual input costs. However, an additional component cost must be added because of a change made in the paper-tape loading and conversion process.

In early March, the PDP-7 satellite computer used for conversion of paper tape to magnetic tape was replaced by a Mohawk Data Sciences 6405 paper-tape to magnetic-tape converter. This device produces nine-channel 800 bpi magnetic tape in Flexowriter code. Since code conversion cannot be done by this machine and since the Compatible Time-Sharing System (CTSS) requires seven-channel tape in a special format, a Project TIP program written for the IBM 360/65 is utilized to convert Mohawk tapes to CTSS-compatible tapes. These tapes are then read directly into a CTSS disc file and are converted from Flexowriter code to ASCII by the CVFILE program which is available on CTSS.

This conversion process is significantly more expensive then the older method of input through the PDP-7 - approximately $4.15 per file as compared with $1.20. This change raises the current cost for input by punched paper-tape means to approximately the same level it was before the change-over in Flexowriter models.

The current cost per file of ten documents for input of paper tape now breaks down as follows:

Keying Operator Costs	$18.45
Computer Processing Time	4.15
Computer Operator Time	0.39
Materials (Paper tape)	0.70
Total (10 documents)	$23.69

EVALUATIONS

Performance Characteristics. The tabulation of comparative performance characteristics which appeared in the 15 September 1970 Semiannual Activity Report has been expanded to include a sampling of 650 documents processed during the first six months of 1971. Most of these were input on-line. Figures for all three samples are contained in Table D-1.

The figures for this 1971 sample are consistently lower than previously reported figures. Average descriptive cataloging times decreased because of the change in corporate author entry formats. This change was discussed in the 15 March 1971 Semiannual Activity Report. Since it was no longer necessary for catalogers to consult a separate corporate author authority file, descriptive cataloging time necessarily diminished. Other changes may be a result of more concise and compact indexing, faster indexers and/or typists. Further analysis will be necessary to determine the exact reasons.

Catalog Record Design. A significant segment of the work being conducted with Intrex system users in the open library environment and in controlled experiments has begun to give new insights into the design of catalog records. Considerable feedback primarily has come from introducing the Intrex System to new users and observing their understanding of the catalog and its component elements. This has led us to believe as a working hypothesis that considerably more attention must be given to the functional roles of data elements both individually and in combination.

Table D-1

Performance Characteristics for Samples Taken January - April, 1968, May, 1968 - June 1970 and February, 1971 - July 1971

Operation (per document)	January 1968 - April 1968	May 1968 - June 1970	February 1971 - July 1971
Subject Indexing (average min.)	28.3	20.2	11.1
Descriptive Cataloging (average min.)	5.4	4.7	2.3
Review of Subject Indexing and Descriptive Cataloging (average min.)	10.4	8.0	5.2
Keying (Including Descriptive Cataloging by Typists) (average min.)	17.1	18.4	15.8
Indexing Time (min. /page)	March '67 - March '68 6.7	3.9	2.0
Keying Time (min. /page)	4.2	3.0	2.8
Average Document Length (pages)	4.2	6.1	5.6
Sample Size (documents)	1666	185	650

As a first step in studying the functional organization of the catalog data, we have prepared an initial list of the present set of 54 data fields which groups each field into one or more of 10 categories (21 data fields appear in more than one category). The categories, which are not the only ones possible, are:

1. Fields Identifying a Document
2. Fields Summarizing the Content of a Document
3. Fields Indicating the Type of Document
4. Fields Indicating the Location of a Document
5. Fields Telling About the Creation of a Document
6. Fields Giving Publication History
7. Fields Giving Additional Bibliographic Data
8. Fields Relating a Document to Other Documents
9. Fields Commenting Upon a Document
10. Fields Most Germane to the Intrex Catalog and Text Systems

This listing was prepared specifically with the user interface in mind and therefore the terminology tries to avoid bibliographic jargon. The complete list contains a set of applicable catalog field definitions for each category in which the definition emphasizes the role of the field in that category. The complete list has been incorporated into various user aids as a first step in observing the utility of the functional organization of catalog fields.

Data-Base Coverage. A new and more detailed listing of the subject areas covered by the Intrex data base has been prepared. The previous listing was merely a brief outline prepared primarily for internal use by systems personnel working with the five core M.I.T. research groups participating in the Intrex experiments. That outline reflected the organization of each of the five research groups. Our work in the open environment has shown that a good explanation of the data-base coverage was important to users and that the outline being used was insufficient for the many system users not associated with one of those groups. Confusion arose because the organizational outline contained redundancies resulting from the overlap in the subject interests of those research groups. Furthermore, the organizational names of the five groups apparently did not convey to non-group members the full scope of group interests. The new listing (see Table D-2), which is based solely upon the totality of subject areas selectively covered within the current Intrex data base, corrects these deficiencies.

Analysis of the Review Process. In the workflow for generating catalog records, a review operation follows the initial steps of subject indexing and descriptive cataloging of each document. The review step, performed by a staff member other than the initial indexer of any given document, takes approximately five minutes and involves a review of the initial catalog and index data for correctness, completeness, legibility for the

Table D-2

Subject Areas of the Intrex Data Base

I. PHYSICS AND ELECTRONICS

A. Magnetic, Optical, Electronic, and Ultrasonic Properties of Materials

1. Raman and Brillouin light scattering
2. Magnetic properties; spin, resonance, relaxation, domains, antiferromagnetism, ferromagnetism, exchange interactions, Kondo effect
3. Nuclear magnetic resonance; nuclear quadrupole resonance
4. Optical properties; birefringence
5. Non-linear optics
6. Lasers and laser spectroscopy; optical pumping; tuneable lasers; laser crystals
7. Luminescence
8. Sound propagation and attenuation; ultrasonics; phonon dispersion
9. Second and third harmonic generation
10. Quantum electronics; quantum magnetics
11. Magnetic, optical, electronic, and ultrasonic interactions: e.g., magneto-optics, electro-optics, electro-acoustics, magneto-elastic, exciton-magnon
12. Faraday, Kerr, and Zeeman effects
13. Ferroelectricity, dielectrics, and insulators
14. Ferrites, garnets, fluorides, perovskites, rare-earths, rare gases
15. Microwave techniques and devices; Gunn effect; parametric oscillators, filters, waveguides, phase shifters, delay lines, strip lines, memories
16. Semiconduction; tunneling, junction phenomena, diodes; Hall effect
17. Charge carrier mobilities
18. Superconduction tunneling; Josephson effect
19. Surface elastic waves
20. Liquid crystals
21. Green's function methods
22. Holography

B. Critical Point Phenomena, Phase Transitions, Thermodynamic and Transport Properties

1. Critical (transition) point phenomena
2. Phase transitions; order-disorder phenomena
3. Equations of state
4. Fluctuations and sound velocity in fluids
5. Critical fluid mixtures and diffusion
6. Liquid helium; second sound
7. Kinetic theory of gases
8. Correlation functions
9. Cooperative phenomena and statistical mechanics
10. Viscosity and transport coefficients
11. Biological macromolecules

Table D-2 (Contd)

II. METALLURGY

C. Mechanical Properties of High Temperature and Structural Materials

1. Crack initiation and propagation
2. Fatigue behavior; thermal fatigue
3. Creep and stress rupture properties
4. Dispersed particle and other strengthening mechanisms
5. Dislocations
6. Plastic deformation; superplasticity
7. Grain boundary properties; grain size effects; intercrystalline cracking
8. Strain rate effects
9. Brittle fracture in rock and concrete
10. Viscoelastic analysis and characterization
11. Strength and fracture of inorganic glasses
12. Composite materials

D. Formation and Structure of Solids

1. Casting and solidification
2. Heat and fluid flow during solidification
3. Rheology of liquid-solid mixtures
4. Nucleation, growth, segregation, dissolution
5. Recrystallization and grain growth
6. Crystal growth
7. Dendritic structures
8. Liquid-solid interface
9. Eutectic alloys; liquid metals and alloys
10. Alloy phase studies of high temperature and structural materials
11. Splat cooling
12. Metastable structures
13. Oxidation resistance; high temperature corrosion
14. Solidification of crystalline polymers
15. Concrete mixtures, aggregates, and hydrated cements
16. Sintering; hot isostatic pressing; hot powder rolling

III. OTHER

1. Computer graphics - (182 documents on graphics systems, display processors, display terminals, peripheral equipment, languages and algorithms)
2. Transportation traffic control - (25 documents on air traffic control, tunnel traffic flow, ground transport)

typists, grammatical structure, possible alternative phrasings, and the like. The review-process policy has remained essentially unchanged since inception, although the time expended has continually decreased. Recently, questions have been raised as to the efficacy and necessity of this process. Therefore, an analysis of the number, type, and reason for corrections made to a sample of 291 records indexed from June 1970 to June 1971 was made.

Since reviewing is actually a two-part process--review of indexing phrases and of descriptive cataloging--the data were gathered in the same two-part manner. Not only were the number of corrections in the subject terms totaled, but the number of individual words involved in these corrections was also recorded. The thirteen common words (a, an, the, etc.) omitted from the subject/title inverted file were ignored in the study. Words were considered to have been added, deleted, or corrected. A change of an assigned range number to an index term was considered to be a separate correction. Data for all other fields included the common words. Words in these fields were also considered in terms of addition, deletion, or correction. A distinction was made between those fields for which students indexers were responsible for generating the data and those for which they were not. This report is concerned primarily with the preliminary results of the subject-term review data.

The reasons for the correction of index terms, as determined during the analysis, were examined. The reasons are briefly defined as follows:

1.	Enhancement	The phrase or phrases were added to complete the information either in the index term or the term set.
2.	Redundancy	The phrase or phrases were deleted to eliminate repetition within the index term or the term set.
3.	Veracity	The phrase or phrases were used to make the fact within the index term or term set accurate.
4.	Synonym Change	The phrase or phrases were replaced by their synonym to create another access point for the term set.
5.	Handwriting	The phrase or phrases were corrected to make handwriting legible.
6.	English	Includes spelling errors, corrections to grammar, phrase structure, punctuation, or field coding.

A few additional reasons, specific to the descriptive cataloging fields, were also used.

Table D-3 outlines the characteristics of the review analysis sample in terms of documents originally indexed by librarians or by students and by both. For this study,

Table D-3

Review Analysis Sample Characteristics

	Librarian Indexers	Student Indexers	All Indexers
Number of Documents Reviewed	188	103	291
Documents without Corrections	44	10	54
Documents with Corrections	144	93	237
Average Page Length Per Document	4.9	6.5	5.7
Average Number of Subject Terms Per Document			
- Range 1	1.0	1.2	1.1
- Range 2	1.8	1.6	1.7
- Range 3	1.1	1.7	1.4
- Range 4	0.37	0.51	0.44
- Range 0	0.13	0.31	0.22
- TOTAL	4.4	5.3	4.8
Average Number of Subject Terms Per Document Page	0.90	0.82	0.84
Average Minutes Per Document			
- Indexing	9.6	14.9	12.2
- Descriptive Cataloging	2.2	3.0	2.6
- Reviewing	4.1	6.1	5.1
Average Minutes Per Page			
- Indexing	2.0	2.3	2.2
- Descriptive Cataloging	0.47	0.42	0.44
- Reviewing	0.85	0.85	0.85

occurrences are defined as the number of times corrections were made, irregardless of the number of words in the correction. The processing figures agree fairly closely with those of a sampling of documents input on-line taken earlier this year and are somewhat lower than those previously reported. (see Table D-1). Of the 291 documents sampled, 18.5% of the total required no correction. In terms of indexer status, 23% of those indexed by librarians and 9.7% of those indexed by students required no correction.

The average number of subject terms per document was 4.8 (4.4 for documents indexed by librarians and 20% more or 5.3 terms for documents indexed by students). There is little difference in the average number of subject terms per document page assigned by these two groups. Average reviewing time was 4.1 minutes for articles indexed by librarians and 6.1 minutes for those indexed by students. Average minutes per page for reviewing was 0.85 for documents indexed by either students or librarians. This figure suggests that there is little difference between the actual times for reviewing documents indexed by students or librarians.

This conclusion is supported by another calculation. To a first approximation, the time spent on review is a function of the length of the document and the amount of indexing required. Thus, the review time for documents in the sample indexed by students would normally be expected to run about 20% higher than the review time on documents indexed by staff librarians, when number of index terms alone is considered, or about 33% higher when number of document pages alone is considered. In the sample, the review time of student-indexed documents runs 49% higher. The additional 16% and 29%, or 0.7 and 1.2 minutes, are primarily accounted for by the additional descriptive cataloging necessary for documents indexed by students. Therefore, cataloger status appears to have little effect on review time. The analysis of the review process is continuing, with attention being given to the individual styles of each reviewer and their relation to individual indexers, to review time, and to the number of corrections made per catalog record.

The number of occurrences of corrections is outlined in Table D-4 by range number and type of correction, i.e., addition, deletion, correction, or range change, in terms of the reason for the correction. Enhancement of the index term or term set is the reason for correction in 46.1% of the total number of corrections during review. The largest percentage of these were added to range 2 subject terms, followed by ranges 3 and 1. The large percentage added to range 1 is somewhat surprising since range 1 may be generally compared to an extended title and that would seem to be easily derivable. The extensive additions to range 2 subject terms reflects the emphasis of indexers and reviewers on including all applicable range 2 index phrases in the term set. This concept is also reflected in the figures for average number of terms per document - 1.7 range 2 terms compared with 1.4 range 3 terms and 1.1 range 1 terms per document. Occurrence of phrases added to range 3 terms are equivalent in number to those added

TABLE D-4

OCCURRENCES OF CORRECTIONS IN INDEX PHRASES

BY

REASON, RANGE AND TYPE (291 Document Records)

Range and Type	Enhancement	Redundancy	Veracity	Synonym Change	Handwriting	English	Total	Percent of Total by Range	Average Number of words per correction	Total number of entire terms added or deleted by type
RANGE 1										
- Added	47	2	1	2		3	55		4.9	8
- Deleted	3	18	1	2		5	29		5.9	12
- Corrected		1	1		23	8	33		1.1	
- Range Change	2						2		2.0	
- TOTAL RANGE 1	52	21	3	4	23	16	119	22.8		20
RANGE 2										
- Added	87		4	8		18	117		5.9	37
- Deleted	5	27	2	7		10	51		4.9	15
- Corrected			4		50	3	63		1.2	
- Range Change	13						13		2.0	
- TOTAL RANGE 2	105	27	10	15	50	37	244	46.7		52
RANGE 3										
- Added	52			2		6	60		7.0	38
- Deleted	2	19	1	2		5	29		7.6	10
- Corrected			1	1	27	3	32		5.5	
- Range Change	6						6		2.0	
- TOTAL RANGE 3	60	19	2	5	27	14	127	24.3		48
RANGE 4										
- Added	15						15		3.8	14
- Deleted		1					1		6.0	1
- Corrected					4		4		1.0	
- Range Change										
- TOTAL RANGE 4	15	1			4		20	3.8		15
RANGE 0										
- Added	8						8		5.4	8
- Deleted		3					3		5.0	1
- Corrected									0.5	
- Range Change	1						1		2.0	
- TOTAL RANGE 0	9	3					12	2.3		9
TOTAL OCCURRENCES BY REASON	241	71	15	24	104	67	522	100		144
PERCENTAGE OF TOTAL BY REASON	46.1	13.6	2.9	4.6	19.9	12.6	100			

to range 1. Since range 3 phrases represent the smaller details of a document, the judgment and particular style of the individual indexer who selected the term is generally accepted without much question. Additions of range 3 index terms are usually made only for glaring omission. Thus, although the total number is lower than that for range 2, it probably does not reflect a higher rate of correct range 3 index terms but rather the prevailing review policy.

Handwriting illegibility is the reason for 19.9% of the total corrections. In this sample covering the work of six indexers, one indexer's work accounted for 53% of the handwriting errors and another indexer for 35% of these errors. It is clear here, then, that the number of handwriting corrections is a function of particular personnel rather than being distributed equally among all staff.

The relatively low number and close distribution of redundancy corrections in ranges 1, 2, and 3 subject terms, when compared with that of enhancement, is due in large part to the naturally redundant character of Intrex-style indexing. As long as a phrase provides some form of alternate wording and is not blatantly redundant, it will seldom be eliminated from the index-term set. Therefore, corrections to eliminate redundancy account for only 13.6% of the total.

English corrections such as grammar, spelling, and punctuation, represent 12.6% of the total number. Here, too, the emphasis is on range 2 terms followed by range 1 and 3. English corrections are those which will always occur.

Synonym changes comprise only 4.6% of the total number of corrections. The number is small when considering that one of the purposes of reviewing is to add as many synonyms as possible that were omitted by the indexer. Thus it would appear that here the indexers are functioning as efficiently as can be expected and that synonyms do not pose a major problem during review.

Corrections due to errors in fact, i.e. veracity, were only 2.9% of the total number of corrections. This number may be somewhat misleading because veracity and enhancement overlap in definition. What may have been considered an error in fact during review, could have been counted as an enhancement correction during review analysis. Therefore it is difficult to make judgements about the role of veracity in the review process.

Analysis of the data gathered for fields other than subject fields is underway. Data for subject phrases and all other fields will be analyzed in terms of indexing style and the relation of reviewing style to it and vice versa. At this stage of the analysis, it appears that review policy could be more clearly defined and that the review process could be de-emphasized for certain categories of data or for certain indexers or a combination of the two.

Comparative Error Analysis of On-Line and Off-Line Input. The number, major contributory cause, and field distribution of errors in files input on-line compared with those errors in files input off-line has been analyzed. The methodology and definitions are derived from the pilot study of data-preparation errors discussed in the 15 September 1970 Semiannual Activity Report. The comparative off-line data were taken from the pilot study which covered a sample of 14 files (140 documents) input off-line between January 1968 and June 1970. The on-line error analysis data came from a sample of 6 files (60 documents) selected randomly over the five-month period from February 1 - June 30, 1971. The on-line input file samples were 11% longer (i.e.,11% more characters) than the off-line input file samples although there was a 16% decrease in the keying time per record for the on-line sample.

The number of discovered errors per file nearly doubled during on-line input of files (from 40.7 for off-line input to 73.9 for on-line input). Mechanical errors, i.e., those directly attributed to machine problems, increased 666% (from 0.69 per file off-line to 4.6 on-line). While the rate of increase is great, the actual number of these errors is still inconsequential in its effect on on-line input. Errors due to typist oversight and miskeying increased 76% and 125% respectively. Together these typist-caused errors account for 72% of all errors in the on-line input files.

This increase in error rate from off-line to on-line input files was quite dramatic, since it was expected that there would be little difference between the two modes of input. At first glance, it might seem that on-line input could be faulted, but on closer examination of the types and causes of errors, it is clear that they can be largely accounted for in the increased keying speed and lack of attention on the part of the keying staff to correcting errors at the time they are made. In other words, the ability to switch between input and edit modes during on-line input is not fully utilized at present. Steps are now being taken to fully integrate the edit and input modes.

A detailed discussion of these findings will be issued in a forthcoming Technical Memorandum.

E. COMPUTER SOFTWARE

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SUMMARY

Documentation initiated during the last reporting period on the retrieval-system software has been completed. The report is due to be published concurrently with this semiannual report.

Several new features have been incorporated into the existing Intrex programs. These features include new on-line output capabilities and a capability for outputting hard copy off-line on a high speed printer. Also included are additional monitoring features, and features that improve program operation and efficiency.

Additional effort was expended in creating a computer-graphics data base. Also, work has begun on programs to remove certain information fields of early documents from the catalog.

The buffer/controller software is being modified to permit two display consoles to operate simultaneously. A preliminary program is in operation which allows users at both terminals to interact with the catalog simultaneously.

RETRIEVAL-SYSTEM SOFTWARE DOCUMENTATION

The programming staff has completed its effort in documenting the Intrex Retrieval-System software. The report includes a description of the approximately three-hundred separate subroutines that comprise the Intrex retrieval programs. The report is scheduled to be released from publication on approximately the same date as this semiannual report.

NEW RETRIEVAL-SYSTEM FEATURES

Several improvements to the Intrex retrieval software were made during this reporting period in the form of new features. These new features relate to additional output capability, extended monitoring of Intrex users, and greater internal efficiency of operation.

New Output Features. Users of Intrex may now ask for catalog data to be output to a disk file; the stored data will then be printed off-line and can be mailed to the user. This capability permits users to review the results of an on-line search on a deferred basis and to obtain permanent hard-copy bibliographies without having to wait for such at a typewriter terminal.

The new feature also opens the possibility for a new mode of searching — the delegated mode — where a user requests a search indirectly through an Intrex staff member who performs the search and sends results to the user. To request off-line output, an on-line user merely includes the argument "OFFLINE" in his output command. Any selected fields may be requested in this mode except full text which has for some time been available off-line in the form of microfilm and will continue to be available that way. Since users generally share the off-line disk file, it is important that each user's output be properly identified. This identification is accomplished in part automatically since Intrex labels the file with the user's name and address typed during the log-in stage. However, to allow a user to better identify his data, a special NOTE command has been implemented. The new command is similar to the COMMENT command but writes the user's message into his offline file instead of the monitor file. This command may be used to head, introduce, identify, or describe the output which follows it (or precedes it) and to provide instructions to the staff for mailing or holding the data. Notes which extend beyond one line of text may be continued onto subsequent lines using a hyphen as a continuation character for each line except the last.

A second new output feature which facilitates quick scanning of documents has also been implemented. An abbreviated form of output for a single specified field may be obtained by including the argument "FAST" in an output command. In FAST mode only the first 45 characters (98 characters for abstract or excerpt) of the selected field are printed. If multiple fields or combined output fields are requested, only the first 45 characters of the first field will be output.

A third feature which should be of considerable utility to Intrex users is the combination of abstract and excerpt field output. The abstract and excerpt remain as separate fields in the augmented catalog (although both are generally not present), but now the command "OUTPUT ABSTRACT" results in a display of the abstract field, or if that field is empty, a display of the excerpt. A new field specification AUTABS (for author's abstract) has been implemented to permit explicit output of only the original abstract. The new specification thus has the same function as the old ABSTRACT specification.

A final improved feature of Intrex was implemented in the command "OUTPUT MATCH" which now results in the display of actual matching titles instead of the dummy expression (TITLE) whenever a match on title terms occurs.

New Monitoring Capabilities. Intrex personnel are now able to bridge a local interactive monitoring console across a user's console at some remote location so that all information typed on either console appears at both. With this new facility, Intrex personnel are able to observe in real time the interactions of any user, to help and advise a user, and to conduct demonstrations at a remote location.

In order to discourage the use of Intrex at unsupervised consoles (especially by frivolous users), a new security device has been implemented. At the start of each Intrex session the console number being used is automatically checked against a list of authorized Intrex console numbers. If the user's console is not on this list, a message is printed informing him of the proper time and place to use Intrex, and his console is automatically logged out. Logout is not executed until the sign-in stage is completed so that the user's sign-in statement can be recorded in the monitor file.

Features for Improved System Efficiency. Several changes to the Intrex Retrieval-System programs were made which are not apparent to Intrex users, but effect overall efficiency and reduce operating cost.

The main printing procedure TYPEIT has been improved in ways which reduce the CPU time required for I/O operations by 65 to 70 per cent. The scheme for line formatting was revised to greatly reduce character shifting, and the nucleus procedure which converts codes and prints them on the console was rewritten in machine language for much greater efficiency.

The more than seven hundred data-base files have been divided between two separate common-file directories in order to reduce search time. System programmers of the CTSS time-sharing computer system advised us that the use of two smaller directories results in a substantial advantage in access time and more than compensates for the small increase in system complexity. The savings to Intrex because of this change is currently being evaluated.

Execution of certain Intrex commands were causing large blocks of "free storage" to be broken into smaller blocks. This sometimes resulted in lack of sufficiently large blocks for certain other operations such as switching between long and short modes of dialog. This problem has been circumvented by more auspicious calls to the free-storage routines and by using a permanently defined array instead of free-storage blocks in some cases where reuse of the storage block was not critical. In addition, a modification was made so that errors in the use of the free-storage procedures now cause a call to the central error-exit procedure ERRGO. This modification permits the closing of the monitor file to preserve the last full buffer of data before the Intrex system escapes to control of CTSS.

In conjunction with an effort to more closely monitor the amount of computer time expended by various components of the retrieval system, a new timing procedure has been written. Because of its lower overhead, this routine permits timing measurements nearer the minimum resolution of 1/60th of a second to be made. Calls to the console output package, TYPEIT, and to the disk I/O procedures are timed and a special command, SUMUP, prints a summary of the current totals for console and disk I/O. Additional software has been loaded which may be evoked for the purpose of executing parts of the Intrex system in interpretative mode. This software will enable the Intrex staff to determine the exact number of instructions required by any given process and thus to determine execution times to microsecond resolution. Much of the older timing data formerly printed in the monitor files has been removed since they are of little informational value. Entries for recording the total time used upon exit from Intrex were retained, however, since they afford a fairly accurate log of system usage and ratio of cpu time to real time. Removal of most monitor-file timing data has allowed the dropping of a fairly sizable subroutine (SUMOUT) which was used for tabulating modular timing data.

A limited debugging capability has been built into the system in the form of special Intrex commands. The command "LOOK loc n" enables a systems programmer to examine n words of core memory beginning at location loc. The command "SEG n" causes the n overlay segment to be read into memory. The command "FREE" prints out the linked list of available free storage.

Several additional small changes were made which result in generally improved operation of the system. The procedure which converts catalog information from digram-encoded ASCII to simple ASCII has been recoded, resulting in a 20% savings in time. Parsing of unusual command combinations which tended to confuse the command interpreter has been improved. Several other bugs of assorted types have been corrected and some obsolete or redundant software code has been deleted.

OTHER ACTIVITIES

The Intrex data base was expanded to a total of 15,848 documents. Further expansion of the data base is being postponed until fall when more normal user activity is expected. Keyed documents were put through the "dry run" phase to detect errors, corrected, and then stored off-line while awaiting the next data base generation. An effort has been started to remove certain information fields of the earlier documents in the data base. This effort involves the writing of special programs for this purpose. The early-document catalog records will be reduced to author, title, and a few other short fields. Retrieval based on terms appearing only in the title will be possible for these documents.

A special data base and Intrex retrieval system were set up for 182 articles on the subject of computer graphics (these articles were also put into the regular Intrex data base). Further information on the nature of this data base can be found in Section II-D of this report.

A short time was spent modifying the code-conversion programs to make them compatible with the new flexowriters used by the input group as back-up to the on-line input procedure.

INTREX DISPLAY SYSTEM BUFFER/CONTROLLER SOFTWARE

The buffer/controller software is being modified to incorporate the second Intrex display console and the expanded magnetic-drum capacity into the Intrex Display System. Software changes required for a redesigned interface between the buffer/controller and the full-text microfiche subsystem are also being made.

A preliminary monitor program is in operation which allows two users, one at each of the Intrex refreshed CRT display consoles, to conduct independent catalog searches simultaneously. The buffer/controller monitor program also controls communications between the two users and the full text microfiche display central station. All features of the earlier, single-console, buffer/controller software are not yet available in the simultaneous two-user program. As additional program segments are modified and debugged and as required hardware becomes operational, corresponding features will be added to the preliminary program.

To allow multiple user access to the microfiche full-text subsystem from the Intrex Display consoles and the buffer/controller, the hardware interface between the 620i computer and the full-text central station was modified. To relax 620i program timing requirements, additional buffering and control of full-text requests within the interface hardware was designed. These hardware changes required special check-out and debugging activities executed through 620i test programs. That check-out is currently in progress.

A similar procedure was followed in bringing the expanded magnetic drum and the second display console into operation. Special 620i test programs were executed to aid hardware check-out and debugging. The preliminary software and new hardware system is currently operating in a shake-down mode prior to a move of one display console to the Engineering Library.

F. HARDWARE

Staff Members

Mr. J. Bosco
Mr. P. Campoli
Mr. J.E. Kehr
Mr. S.G. Kuyamjian
Mr. D.R. Knudson
Professor J.F. Reintjes
Professor J.K. Roberge
Mr. J.O. Silvey

Graduate Students

Mr. R. Goldschmidt
Mr. Y. Chan

SUMMARY

The second Intrex display console and an associated text display have been completed. The new 128-track drum in the buffer/controller is operating satisfactorily after interference caused by cross-coupling between the read and write signals was eliminated. Techniques for allowing separations between the buffer/controller and the display console of 2000 feet, maximum, are being studied and tested in preparation for locating the second display console in the Barker Engineering Library.

The text-access interface in the buffer/controller has been redesigned to relieve the computer of the time-consuming control of text request messages which permits more efficient software for the two-console program. The new-interface hardware provides the required sequencing of data transmission between the buffer/controller and the text-access central station.

A significant decrease in the failure rates of the microfilm-retrieval units has been achieved after retrofitting these devices with redesigned components and providing improved maintenance via a service contract with the manufacturer.

A comprehensive study of the computer-storage requirements for a large-scale library system has been completed as part of a doctoral program by Mr. R.E. Goldschmidt. It proposes a new type of mass-storage device together with an appropriate queing algorithm and file organization for a one-million-entry catalog and 240 on-line users.

The vertical-screen, wall-type microfiche viewer has been evaluated by users in the Barker Engineering Library.

THE INTREX DISPLAY CONSOLES

The hardware for the second Intrex Display Console has been completed and the two-console software for the display buffer/controller is currently being developed (see Computer Software section of this report). Adding a second display terminal required the installation of a new magnetic-drum memory with increased storage capacity and the capability to simultaneously read and write on different tracks. Initially, one console's write signals interferred with the others read signals, but this problem has been eliminated by reducing the cross-coupling between the circuits and redesigning the read preamplifier.

At present both terminals are connected to the buffer/controller by less than 100 feet of coaxial cable. However, current plans call for locating the second console in the Barker Engineering Library, a distance of approximately 1800 feet from the buffer/controller. Communications between the buffer/controller and the terminals is designed for full-duplex transmission of bipolar pulses at 1.2 Megabits per second. Because the longer cable distorts the transmitted pulses, tests are underway to determine the design modifications necessary to operate with cable lengths up to 2000 feet.

Magnetic-Drum Memory. The new drum memory has 128 tracks, each of which can store a full page of display data, and three independent read-write heads. Each of the two display terminals has been allocated 16 separate tracks; the remaining 96 tracks are used for system and programming purposes. One of the principal reasons for installing a new drum is to allow each of the two users at the display terminals or the computer to simultaneously perform read-write operations.

As might be expected, the signal current required to write data on the drum is much greater than that required in the read signal. When the new drum was initially installed it was found that the process of writing data on the drum for one display caused considerable interference in the data being read for the other display. Eventually the problem was traced to circuitry located under the drum shroud. The read preamplifiers were replaced with circuits designed to improve their common-mode rejection, and the critical signal-carrying leads were rerouted and shielded to reduce cross coupling. These changes eliminated the interference, and the drum has been operating reliably for several months.

Data Transmission. The display consoles communicate with the buffer/controller at a data rate of approximately 1.2 Megabits per second. Over coaxial-cable distances of 2000 feet the rise-and-fall times of the digital pulses increase to approximately 200 nanoseconds, and the signal is decreased to about 2/3 its original amplitude. The degradation of the digital signals can cause problems in this system and these have been investigated in a graduate thesis by Mr. Y. T. Chan.

It is economically attractive to use full-duplex data transmission for longer distances because only one cable is required for two-way communications. The original design included full-duplex transmission utilizing directional couplers at each end of the cable. These devices separate the signals in the two directions but their adjustment becomes more critical when operating over longer cable lengths.

Tests using a 2000-foot full-duplex cable have shown that high error rates are experienced with the original design. Redesign and further testing are proceeding to determine if the full-duplex scheme can be implemented. If not, alternative plans include use of two separate cables for transmit and receive and/or repeaters located part-way along the cable.

FULL-TEXT STORAGE AND RETRIEVAL

The storage-tube display for providing text access at the second Intrex display console has been completed. However, the buffer/controller interface with the text-access central station had to be modified to accommodate the two-console buffer/controller software. The previous interface relied on the computer to control the "handshake" routine and the three-data-word sequence for transmitting text requests to the central station. This process occupied the computer for relatively long periods (tenths of seconds to several seconds), depending on the availability of the central station. The computer could afford this time with only one console, but in the two-console system it must be available to process data for the other console. Therefore, the interface was redesigned to control the handshake messages by hardware and to permit the computer to output text requests to the interface without delays.

The redesigned interface includes three buffer registers into which the buffer/controller computer loads the three data words associated with a single text request. After the three words are loaded, the hardware signals the text-access central station that it has a request. The central station responds with the "handshake" message as soon as it is available to receive the data. The time for this process can vary from 250 milliseconds to over ten seconds depending on the availability of the central station. However, the computer is occupied for only a few microseconds and is therefore available to process data for the other console. The hardware for the new interface has been completed and tested.

The Compact Automatic Retrieval Devices (CARD's) used to store the Intrex microfiche collection were retrofitted with new mechanical assemblies to improve their reliability and a maintenance contract has been negotiated with the manufacturer, Image Systems, Inc. to service the two CARD units. The daily operation log shows a significant improvement in performance as a result of the equipment overhaul and improved maintenance. CARD 1 has averaged 215 cycles per failure since the improvements were made, compared to about 58 cycles per failure before. The second CARD has averaged 266 cycles per failure after, and 90 cycles per failure before, the retrofitting.

A test fiche has been developed to calibrate the text-access video system. The fiche has an assortment of resolution charts, sample text images, Moire patterns, Ronchi rulings, and geometrical shapes. These patterns will facilitate the electronic and optical focusing of the flying-spot scanner, edge-finding adjustments for proper page-centering, remote-terminal linearity adjustments, film-terminal grey-level determination, and resolution adjustments. The test fiche is included in the microfiche store and can be retrieved automatically by means of its fiche number.

FILE DESIGN FOR COMPUTER PRESIDENT LIBRARY CATALOGS

In his thesis submitted for the Doctor of Philosophy degree, Dr. R.E. Goldschmidt has made an exhaustive study of file design for computer-stored library catalogs in the 1-million document category. The treatise centers on several topics: the relationship between file requirements and limitations of currently available storage devices; the ability of a combination of queueing algorithm and data organization to bridge the gap between file requirements and storage-device capabilities; and access methods which permit rapid mapping from the symbolic name of a file entry to the file entry itself.

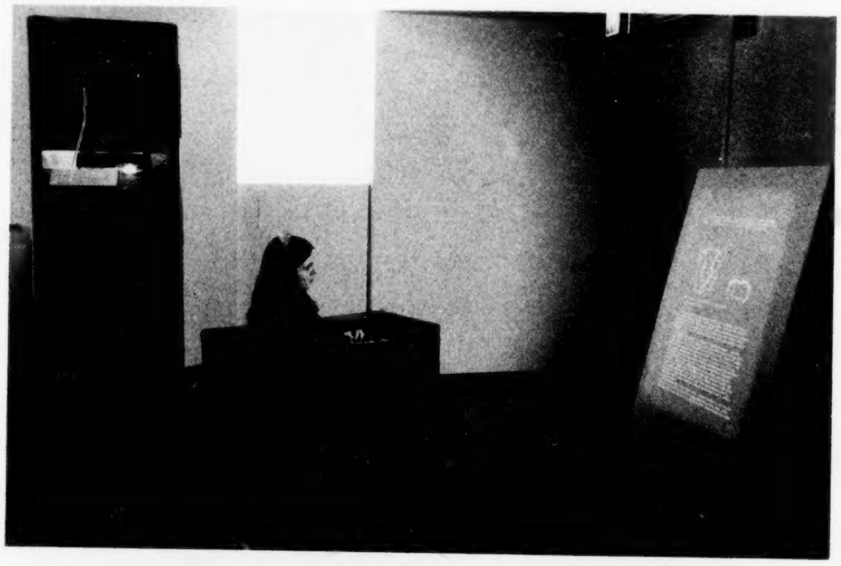
There has emerged from the investigation a paper design for a new storage device which embodies the transfer of information from magnetic tape to magnetic tape and which provides an information capacity of from 10^9 bits for a 3-sec period of medium motion to 10^{10} bits for a 21-sec period of motion. An array of eight devices, each having a capacity of 2.5×10^9 bits and a period of motion of eleven seconds is sufficient to contain a 2×10^{10}-bit catalog. It should be possible to include 1-million entries with this bit capacity. When operated in conjunction with a first-in first-served queueing algorithm with dynamically varying priority, the array of eight devices provides forty accesses per second into the catalog file, which is adequate to serve 240 concurrent users.

The thesis is being published as Electronic Systems Laboratory Report ESL-R-451.

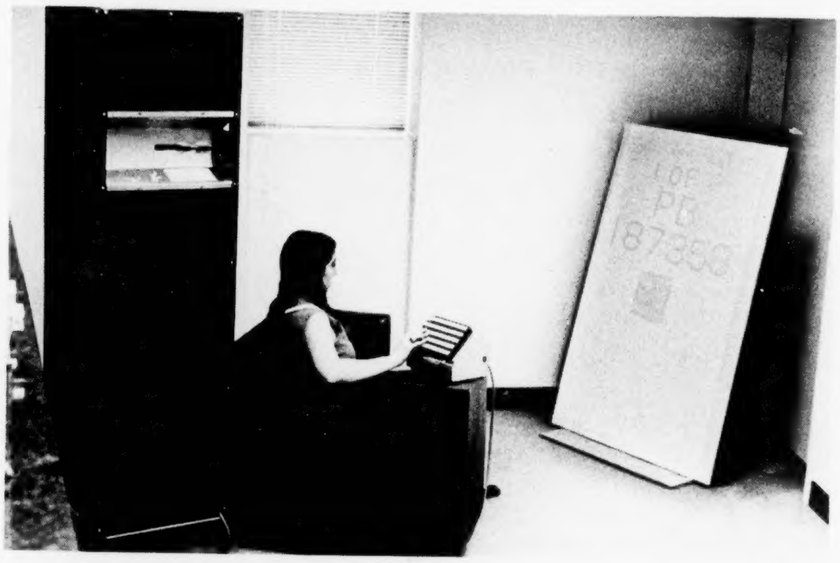
VERTICAL-SCREEN MICROFICHE VIEWER

The vertical-screen microfiche viewer developed under a U.S. Office of Education grant and described in the 15 March 1971 Intrex Activities report has undergone tests in the Barker Engineering Library. Photographs of the installation which were included in the preceding report are reproduced in Fig. IIF-1 for easy reference.

The results of a questionnaire returned by 60 users are presented in Fig. IIF-2. These users were persons who requested microfiche for document viewing and who either found their way voluntarily to the viewer or were asked to try it. Forty of the users operated the system with the velocity-control transport system (a simpler mechanism, but less easy to operate than the position-control transport). Their responses to question 6 are shown enclosed in a rectangle in Fig. IIF-2. The remaining twenty users operated the viewer equipped with the position-control transport system, and their responses to question 6 are enclosed in an ellipse.



(a) Vertical-Screen Viewer Equipped with Velocity Control



(b) Vertical-Screen Viewer Equipped with Position Control

Fig. IIF-1 The Electronic Systems Laboratory Vertical-Screen Viewer Installed at the M.I.T. Barker Engineering Library

QUESTIONNAIRE - EXPERIMENTAL MICROFICHE READER

1. About how many minutes did you view the reader? 29 average (See text)

2. When using this reader, was your sitting position more or less comfortable than your sitting position at standard microfiche readers?

   more comfortable 85 % less comfortable 5 % about the same 10 %

3. What are your feelings about sitting at a distance from a large screen (as with this reader) rather than sitting close to a small screen (as with standard microfiche readers)?

   75 % I like sitting at a distance from a large screen.
   14 % I like sitting close to a small screen.
   11 % There isn't much difference.

4. How did you find -

   a. Image sharpness:
   Good 63 %
   Fair 33 %
   Poor 4 %

   b. Image-to-background contrast:
   Good 74 %
   Fair 26 %
   Poor -

   c. Image brightness:
   Too bright 4 %
   Too dim 5 %
   OK 91 %

   d. Image size:
   Too big 5 %
   Too small 7 %
   OK 88 %

   e. Screen height:
   Too low 21 %
   Too high 4 %
   OK 75 %

5. Did you notice significant image distortion?

   Yes 8 % No 92 %

6. Compared with the manual positioning controls on the other microfiche readers, did the automated position controls of this reader make it easier or harder to find a page?

   Easier to find a page □ 39 % ◯ 88 % Harder to find a page □ 45 % ◯ - About the same □ 16 % ◯ 12 %

7. Compared to translucent rear projection screens typical of standard microfiche readers, was this screen easier or harder on the eyes?

   Easier on the eyes 71 % Harder on the eyes 13 % No difference 16 %

8. Other comments:

□ = responses with velocity-control transport
◯ = responses with position-control transport

Fig. IIF-2 Questionnaire for Evaluation of Vertical-Screen Viewer

III. MODEL LIBRARY PROJECT

A. STATUS OF THE PROJECT

Mr. C. H. Stevens

Since March 1971 the main objectives of the Model Library Project have been the completion of the initial components of the work begun in the fall of 1969 and the sharing of the results of that work with increasing numbers of library users and librarians. These users and visitors have given us strong encouragement to continue and to broaden the programs of the Project. They have emphasized for us the importance of providing a model that will demonstrate for other research libraries some possible steps to be taken in the transition from traditional library services to those that have a strong dependence on the technology of media, computers, photography, reprography, and micromaterials. We have, with the help of these users and visitors, identified areas for attention in the period just ahead and we are preparing a supplemental program of activities and tests as well as a plan for continuing and enlarging the visitor program.

Point-of-use instructional aids have been further developed with improved scripts and more compact hardware. User comments indicate continuing favorable response. The pressure to extend the idea to more library tools and to make both hardware and software available to other libraries has been strong and we are making efforts to be responsive. We sense the need to make the equipment both smaller and less expensive but this is not easily achieved. The offer by a few librarians to assist with script writing and perhaps with filming is warmly welcomed.

Library Pathfinders have now been introduced in England, Ireland, and Canada as well as in most of the United States. There is much interest in their development and use. More libraries and library schools are now cooperating in Pathfinder compilation and we have a considerable backlog to be edited and printed. Some major publishers of library materials have indicated a strong interest in making Pathfinders available through their regular marketing channels. We are exploring this possibility and expect to reach a conclusion by 1 January 1972.

Studies involving user preference for hard copy or microfiche have progressed as the collection has grown and this report indicates an increasing acceptance of microfiche for guaranteed access to theses, reports, and some portions of the journal collection.

B. POINT-OF-USE INSTRUCTION

Staff Members

Mr. C.H. Stevens
Miss M.P. Canfield
Mr. J.J. Gardner

The point-of-use instruction program continued with the testing of user acceptance of the existing instructional programs and the placement of three additional programs in the Barker Engineering Library. Emphasis has been placed on measuring user reactions to various types of media and various content approaches.

New programs in operation include a revised introduction to Engineering Index; an introduction to the Intrex catalog and text access system; and an introduction to Science Citation Index.

The Engineering Index program is in synchronized sound-slide format and runs just under three minutes. It is presented in a self-contained unit designed and fabricated in conjunction with the M.I.T. Audio-Visual Department (Fig. III-1). The unit consists of a fully enclosed cabinet containing a LaBelle Plamatic audio unit, a Kodak Carousel slide projector with a Buhl right angle lens, and a rear projection screen. The unit is activated by lifting a standard hand phone from its cradle and shuts down automatically at the program's conclusion. It is easily portable, measuring 12" deep x 20" wide x 12" high.

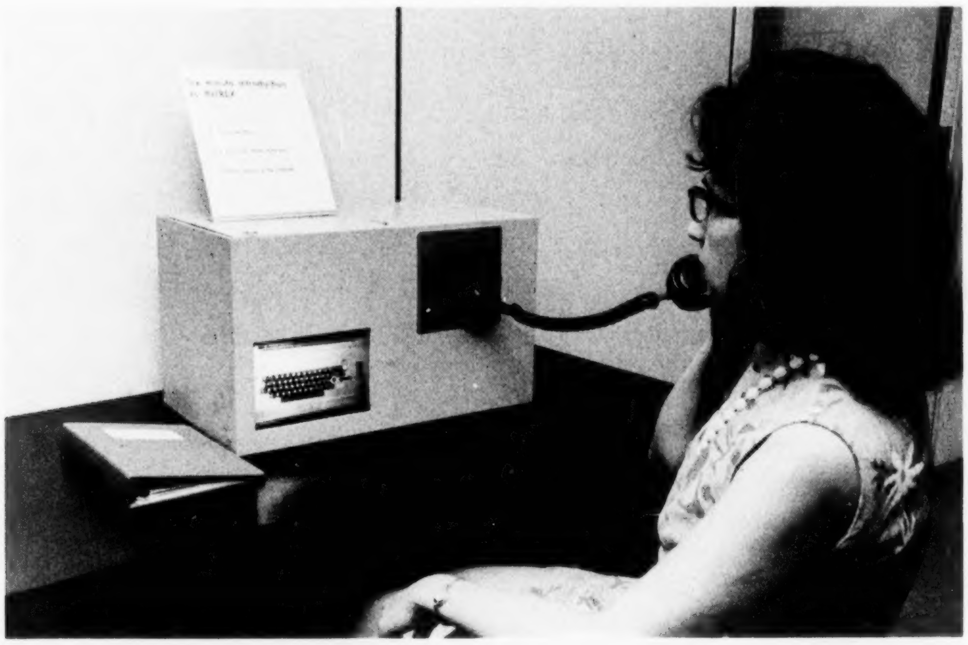


Fig. III-1 Sound-slide projection unit used for introduction to Intrex and Engineering Index programs in Barker Engineering Library.

The introduction to the Intrex catalog and text access system is a six minute synchronized sound-slide program, presented in a unit identical to that used for the Engineering Index program.

The Science Citation Index instructional program is an audio presentation utilizing pre-marked sample pages in an adjacent notebook. The program runs for 5 minutes, 30 seconds and is presented in an audio unit also designed and fabricated in conjunction with the M.I.T. Audio-Visual Department. This unit consists of a standard hand phone set and a small cassette player (Fig. III-2). It utilizes an endless, continuous loop cassette programmed to shut down at the program's conclusion and can be either AC or battery powered. The unit measures 8" deep x 11" wide x 3 1/2" high.

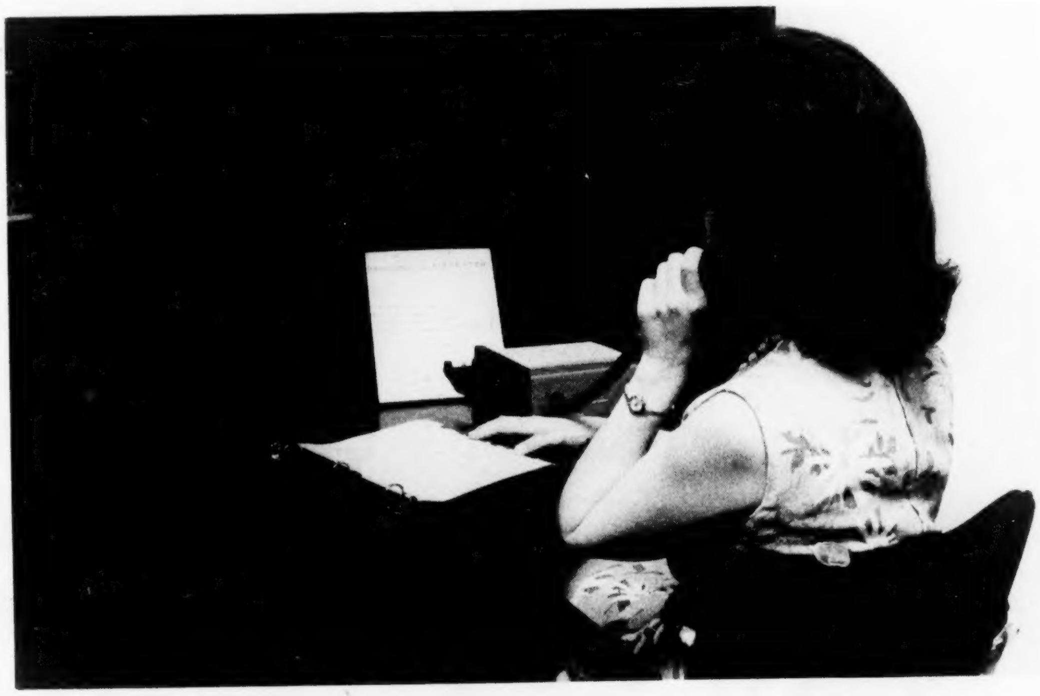


Fig. III-2 Audio unit used for NASA STAR and Science Citation Index programs in Barker Engineering Library.

The audio program discussing NASA STAR has been shifted from the Aeronautics and Astronautics Library into the Barker Engineering Library where it has received enough use to begin to compare its effectiveness with that of the sound-slide program on the same reference source. The sound-slide program on NASA STAR, reported on in the preceding semiannual, has been edited and placed in the Aeronautics and Astronautics Library. There is no significant feedback on this edited program at this time.

The chief source of user reaction to the point-of-use programs has continued to be the comment notebooks located next to each unit. The comments to date on each program fall into categories as follows:

Subject Catalog	Responses	Percent
1. Uncritically favorable	25	33.3
2. Favorable with reservations	20	26.7
3. Favorable to the concept; unfavorable to specific program	13	17.3
4. Totally unfavorable	4	5.3
5. Irrelevant	8	10.7
6. Equipment problems	5	6.7
Author-Title Catalog		
1. Uncritically favorable	29	43.3
2. Favorable with reservations	20	29.9
3. Favorable to the concept; unfavorable to specific program	5	7.5
4. Totally unfavorable	3	4.5
5. Irrelevant	4	6.0
6. Equipment problems	6	9.0
NASA STAR (audio)		
1. Uncritically favorable	18	66.7
2. Favorable with reservations	6	22.2
3. Favorable to the concept; unfavorable to specific program	0	0
4. Totally unfavorable	0	0
5. Irrelevant	4	6.0
6. Equipment problems	1	3.7
Engineering Index		
1. Uncritically favorable	34	57.6
2. Favorable with reservations	15	25.4
3. Favorable to the concept; unfavorable to specific program	1	1.7
4. Totally unfavorable	3	5.1
5. Irrelevant	3	5.1
6. Equipment problems	3	5.1
Introduction to Intrex		
1. Uncritically favorable	5	25.0
2. Favorable with reservations	6	30.0
3. Favorable to the concept; unfavorable to specific program	0	0
4. Totally unfavorable	0	0
5. Irrelevant (Discusses Intrex system rather than A/V program)	7	35.0
6. Equipment problems	2	10.0

The program discussing Science Citation Index has not been in use long enough to produce significant user response.

The combined comments for all the programs fall into categories as follows:

		Responses	Percent
1.	Uncritically favorable	111	44.4
2.	Favorable with reservations	67	26.8
3.	Favorable to the concept; unfavorable to specific program	19	7.6
4.	Totally unfavorable	10	4.0
5.	Irrelevant	26	10.4
6.	Equipment problems	17	6.8

The comments provide strong evidence that point-of-use instruction is a viable, effective method of introducing library users to reference sources. Only 4% of the comments made on all the programs were totally unfavorable, while 44% were favorable without reservation.

There is no indication that there exists a significant difference in effectiveness between programs done in a straightforward manner and those including non-instructional, humorous elements. Only a small percent (8%) of users indicated disapproval of the inclusion of this non-instructional material, while 7% specifically commented favorably on it.

The length of the programs was acceptable to all but 1% of the commenting users but 10% indicated a willingness to accept lengthier programs giving more detailed information.

Equipment problems were, for the most part, resolved after an initial problem period of a few weeks for each unit. The most frequent problem was loss of synchronization between audio and visual. The second most frequent problem has been the simple matter of projector lamps needing replacement. Since the initial synchronization problems were resolved, all machines have had high reliability. A related problem of some concern has been the deterioration of the film-strips used in the catalog programs. This is primarily a problem of dirt and dust but requires more attention than has been necessary for the programs utilizing slides.

In general, sound-slide format offers important advantages over sound-filmstrip. Editing flexibility is the most important of these, but the relative ease of production of slide programs and more general availability of slide projection equipment are other important considerations.

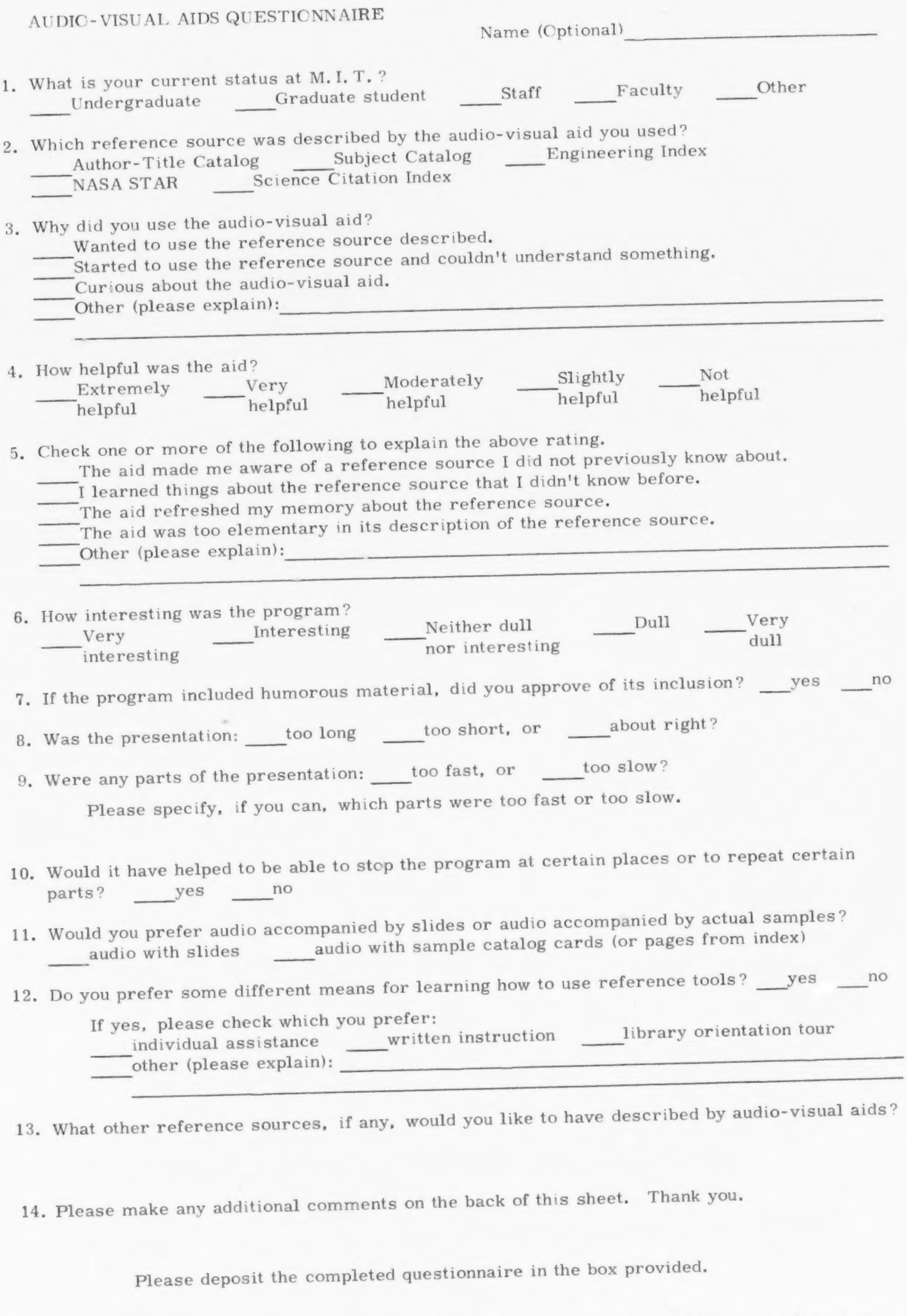
The audio program for NASA STAR was compared favorably to the earlier sound-slide program on STAR by five users who had used both. Their comments indicated that the use of sample pages is instructionally more effective than the use of slides - at least for reference sources of some complexity. However, the sound-slide program on Engineering Index, a less complex source than STAR, proved to be adequate and had the advantage of attracting more use than the audio program. Although the point-of-use concept revolves around the user receiving library instruction at the time he actually needs it, use of the programs for curiosity must be counted as a plus benefit. So while audio with sample pages may be slightly more effective instructionally, the sound-slide format will probably get more use.

The comments received to date have served as a basis for a questionnaire which has been placed at each point-of-use unit (Fig. III-3). We expect to acquire enough results this fall to judge the program's success more definitively and objectively than has been possible with the comment notebooks.

Our efforts at sharing the programs continue through a loan policy which has led to the implementation of programs at the Yale Engineering Library, Lowell Technological Institute, and Sir George Williams University in Montreal. The sharing has included both programs and equipment design and we will be receiving feedback on the programs' effectiveness from these institutions in the fall.

The major emphasis in the point-of-use program during the coming months will be increased sharing of the programs and the equipment and more specific analysis of user response via the questionnaires. Sound-slide and audio units are being made available to other institutions by the M.I.T. Audio-Visual Department, and copies of the programs will continue to be freely loaned for viewing and/or duplication.

Tentative plans are being formulated for production of additional programs, including introductions to Chemical Abstracts, International Aerospace Abstracts, and Government Reports Index, and an instructional program on patent searching. Finally, as new programs are prepared, equipment improvements will be made whenever needed.



AUDIO-VISUAL AIDS QUESTIONNAIRE

Name (Optional)____________________

1. What is your current status at M. I. T. ?
____Undergraduate ____Graduate student ____Staff ____Faculty ____Other

2. Which reference source was described by the audio-visual aid you used?
____Author-Title Catalog ____Subject Catalog ____Engineering Index
____NASA STAR ____Science Citation Index

3. Why did you use the audio-visual aid?
____Wanted to use the reference source described.
____Started to use the reference source and couldn't understand something.
____Curious about the audio-visual aid.
____Other (please explain):____________________
____

4. How helpful was the aid?
____Extremely helpful ____Very helpful ____Moderately helpful ____Slightly helpful ____Not helpful

5. Check one or more of the following to explain the above rating.
____The aid made me aware of a reference source I did not previously know about.
____I learned things about the reference source that I didn't know before.
____The aid refreshed my memory about the reference source.
____The aid was too elementary in its description of the reference source.
____Other (please explain):____________________
____

6. How interesting was the program?
____Very interesting ____Interesting ____Neither dull nor interesting ____Dull ____Very dull

7. If the program included humorous material, did you approve of its inclusion? ____yes ____no

8. Was the presentation: ____too long ____too short, or ____about right?

9. Were any parts of the presentation: ____too fast, or ____too slow?
Please specify, if you can, which parts were too fast or too slow.

10. Would it have helped to be able to stop the program at certain places or to repeat certain parts? ____yes ____no

11. Would you prefer audio accompanied by slides or audio accompanied by actual samples?
____audio with slides ____audio with sample catalog cards (or pages from index)

12. Do you prefer some different means for learning how to use reference tools? ____yes ____no
If yes, please check which you prefer:
____individual assistance ____written instruction ____library orientation tour
____other (please explain): ____________________
____

13. What other reference sources, if any, would you like to have described by audio-visual aids?

14. Please make any additional comments on the back of this sheet. Thank you.

Please deposit the completed questionnaire in the box provided.

Fig. III-3 Questionnaire to be completed by users of point-of-use instructional programs.

C. PATHFINDERS

Staff Members

Mr. C. H. Stevens
Miss M. P. Canfield
Mr. J. J. Gardner
Mrs. E. King
Miss K. Kugell
Miss J. Staffier

During this reporting period 77 Pathfinders have been prepared for publication. The titles are listed below in arbitrarily selected categories:

Architecture

- Bauhaus
- Byzantine Architecture
- Medieval Architecture
- Moorish Architecture
- Romanesque Architecture in Europe

Art

- American Folk Art
- Book Illumination
- Donatello
- Flemish Realism
- French Impressionism
- Giorgione
- Monumental Brasses
- Renaissance Art - Venetian School
- Pierre-Auguste Renoir
- J.M.W. Turner

Biomedical Engineering

- Artificial Blood Circulation
- Artificial Kidney
- Artificial Limbs - Myoelectric Control
- Artificial Organs - Heart
- Blood - Circulation
- Visual Perception

Business and Economics

- Management Games
- Minimum Wage Laws - U.S.

Education

- Bilingual Education - U.S.
- Education in Colonial New England
- Sex Education

Engineering

- Air Conditioning
- Earth Structures - Dams
- Image Transmission Systems
- Oceanography
- Offshore Structures
- Operations Research
- Rheology
- Time-Lag Systems
- Underwater Acoustics

History

- Great Proletarian Cultural Revolution
- Medieval Manor
- New South
- U.S. Pacifism, 1940+

Information Science

- Automatic Abstracting
- Faceted Classification

Literature

- Addison and Steele
- Classical Mythology in Modern English Literature
- Eighteenth Century English Journalism
- Icelandic and Old Norse Sagas
- Jonathan Swift
- La Pleiade
- Puritanism in American Literature
- Romantic Movement in German Literature

Music

- American Folk Music
- Johann Sebastian Bach
- Baroque Music
- Early Music Printing
- History of Opera
- Igor Stravinsky

Political Science
- Apportionment of State Legislatures
- City Government - Council-Manager
- Urbanization in America

Science
- Beam-Plasma Interactions
- Cartography
- Crystal Defects
- Glass
- Group Theory
- Insect Sex Attractants - Biological Control
- Mathematical Logic
- Neutrinos
- Nucleation
- Plant Physiology - Photosynthesis
- Quarks
- Set Theory
- Soil Microbiology - Nitrogen Cycle
- Sunspots
- Zeeman Effect

Sociology
- Alienation
- Juvenile Delinquency
- Utopian Socialism
- Witchcraft

All of these Pathfinders were supplied by participants in the cooperative compilation program and subsequently edited and prepared for publication by the Model Library staff. The large number of titles in the humanities and social sciences reflects an effort to broaden the potential appeal of Pathfinders and stimulate interest in them among a larger group of librarians and library users.

At present the institutions participating in the cooperative program number 24: 13 library schools, 9 university libraries, and 2 special libraries. Since January, 1971, a total of 320 Pathfinder compilations have been submitted by the cooperating institutions (Fig. III-4). One hundred twenty-two compilations have been considered for publication by the Model Library staff, 45 have been rejected, and the 77 listed at the beginning of this section have been edited and prepared for publication.

During the next reporting period the Model Library staff will consider for publication 198 Pathfinder compilations already received from cooperating institutions. We will continue the cooperative compilation program but we will restrict our contacts to those institutions interested in compiling or using Pathfinders on current, high-interest topics in engineering, science and technology.

Because of the volume and diversity of Pathfinders received from cooperating institutions, two temporary members were added to the Model Library staff to work exclusively on editing during the summer period. One of these staff members was an experienced professional librarian; the second was a recent library school graduate with reference experience.

The mechanics of reproducing multiple Pathfinder copies from Pathfinder masters has been simplified by replacing the 11-1/2 x 14-inch master with an 8-1/2 x 11-inch master. This change will eliminate the photoreduction step previously required before libraries could provide Pathfinders to their users.

Participant	Number of Pathfinder Compilations Submitted	General Subject Disciplines Represented
Library Schools		
Case Western Reserve University	38	Information Science Medicine
Florida State University	22	Social Sciences
Kent State University	9	Humanities
McGill University	7	Science
Rosary College	57	Humanities
Simmons College	85	Science; Social Sciences Engineering; Humanities
Texas Woman's University	8	Humanities; Engineering
University of British Columbia	13	Science
University of Denver	36	Social Sciences
University of Houston	2	Science
University of Illinois	16	Science; Social Sciences Humanities
University of Minnesota	1	Science
University of North Carolina	3	Humanities
University Libraries		
Duke University School of Engineering Library	4	Engineering
M.I.T. Rotch Library	1	Political Science
Swarthmore College DuPont Science Library	2	Science
Tufts University Library	2	Science; Sociology
University of Colorado Libraries	1	Science
University of Massachusetts (Amherst) Library	1	Humanities
University of New Hampshire Library	2	Science; History
University of Pittsburgh Hillman Library	1	Sociology
Yale University Engineering and Applied Science Library	2	Science
Special Libraries		
Johns Hopkins University Applied Physics Laboratory Library	6	Physics; Engineering
Commonwealth of Massachusetts Department of Education Educational Reference Center	1	Education

Fig. III-4 Library schools and libraries compiling Pathfinders in the cooperative program.

At present, the majority of compilations received through the cooperative program originate as assignments completed by library school students. We know through communications with professional librarians that the low level of their participation does not reflect a lack of interest in Pathfinders, but rather is a consequence of the lack of available staff time for special projects. We are, therefore, planning to contact interested librarians for the purpose of developing another method by which they can participate in the cooperative program. This alternative procedure would involve the librarians in systematically obtaining staff and user feedback concerning the effectiveness of Pathfinders in their own libraries. The Model Library staff will: (1) provide guidelines for handling the mechanics of this procedure; (2) supply the standard questionnaire and directions for preliminary analysis; and (3) perform the analysis of the information obtained. This method of participation in the cooperative program will be mutually beneficial. The participating libraries will be able to make Pathfinders available as a service to their users without committing staff time for compilation. The time involved in circulating questionnaires and analyzing them in a preliminary way will be minimal. The feedback concerning Pathfinder effectiveness from reference specialists and library users working in the areas of social sciences and humanities will provide evaluative information that cannot be obtained by the Model Library staff at M.I.T.

The investigation continues with Project TIP (Technical Information Project), concerning the feasibility of the computer processing of Pathfinder text. A sample group of 15 Pathfinders has been produced and a cost analysis is in progress. The preliminary indications are that the advantages of format flexibility and ease of revision afforded by the computer production of Pathfinders do not justify the increase in costs over manual production.

During the period February through July, 1971, 865 Pathfinders were distributed on request to Barker Engineering Library users for their retention. The Pathfinders on topics in the area of environmental pollution accounted for the highest frequency of requests.

The general response of M.I.T. users to the engineering Pathfinders continues to be enthusiastic. Actual user comments include:

> "....this project was well worthwhile... Indeed a great service to the library user."
>
> "Sufficiently comprehensive for a good start in searching."
>
> "The Pathfinder was a great aid to me... saved... time searching references for a term paper."
>
> "The Pathfinder was quite helpful... It cut looking-up time at least in half."

A refined questionnaire (Fig. III-5) for obtaining user feedback has been put into use. During the second semester the questionnaire was sent to a sample of Barker Engineering Library users who had requested Pathfinders. Sixty-seven returns were made. Thesis research, course paper research, and personal interest were cited almost equally as reasons for which Pathfinders were taken.

The responses to question #6 concerning the users' judgments of the utility of Pathfinders were as follows:

#6. How helpful was the Pathfinder?	Responses*	Percent
Extremely helpful	7	11.7
Very helpful	21	35.0
Moderately helpful	21	35.0
Slightly helpful	8	13.3
Not helpful	3	5.0

(*N=60; 7 respondents who had not yet used the Pathfinder did not reply to the question)

All the Pathfinder sections are being used but with selectivity on the part of individual users. Most respondents used only one to three sections; none used all sections. The "frequently mentioned texts" section was used more than twice as often as other sections. The remaining sections, however, were all used with enough frequency to warrant continued inclusion.

The reasons most often selected to describe how the Pathfinders had been helpful to users are indicated by the responses to question #7.

#7. In what way was the Pathfinder helpful?	Responses*
Saved time	46
Would not have found references otherwise	16
Made me aware of kinds of library sources available	23
Other	8

(*Many respondents indicated more than one reason)

Finally, 26 respondents identified 62 research areas as their choices for future Pathfinder coverage.

During this reporting period, some possibilities for the commercial publication of Pathfinders have been explored. Preliminary discussions were held with four major publishers of materials for libraries. Two of the publishers subsequently indicated a substantial interest in establishing the mechanisms for publishing, marketing, and distributing Pathfinders. One proposal has been received and the second is expected soon.

Name (optional) ______________________________

1. What is your current status at M.I.T.?
    ____ Undergraduate
    ____ M.S. candidate
    ____ Ph.D. candidate
    ____ Staff
    ____ Other (specify) ________________
    ____

2. How did you learn about Pathfinders?
    ____ Engineering Library Subject Catalog
    ____ Referred by Professor
    ____ Engineering Library Bulletin
    ____ Librarian
    ____ Sample notebooks in library
    ____ Other (specify) ____________________

3. For what kind of research did you intend to use the Pathfinder?
    ____ Thesis research
    ____ Course paper research
    ____ Personal interest
    ____ Other (specify) ____________________

4. Have you used the Pathfinder yet? ____ yes ____ no
    If yes, answer questions 5 - 7.

5. Which sections did you use?
    ____ Subject catalog headings
    ____ Frequently mentioned texts
    ____ Handbooks, encyclopedias, and dictionaries
    ____ Bibliographies
    ____ Journal abstracts and indexes
    ____ Journal titles
    ____ State-of-the-art reviews and conference proceedings
    ____ Technical report indexes

6. How helpful was the Pathfinder?
    ____ Extremely helpful ____ Very helpful ____ Moderately helpful ____ Slightly helpful ____ Not helpful

7. In what way was the Pathfinder helpful?
    ____ Saved time
    ____ Would not have found references otherwise
    ____ Made me aware of kinds of library sources available
    ____ Other (specify) ____________________
    ____
    ____
    ____
    ____

8. How would you improve the Pathfinder you used? (e.g., specific additions, deletions)

9. How would you improve Pathfinders in general? (e.g., addition of type of material; different format)

10. Are there certain research areas you would like to see covered by Pathfinders? Please specify.

Pathfinder No: ______________

Fig. III-5 Questionnaire sent to individual Pathfinder users

D. USER PREFERENCE STUDY

Staff Members

Mr. C.H. Stevens
Mr. J.J. Gardner
Miss C. Keator
Mr. J. Kyed

This reporting period has seen a substantial increase in the use of the Barker Library's Microform Service Area. The increase appears to have resulted from three factors: 1) the growth of the microfiche collection which now includes M.I.T. engineering theses, high demand journal titles, professional society papers, report literature, and the documents included in the Intrex system; 2) the substantial efforts made at publicizing the collection; and 3) the Barker Library's acquisition of portable fiche readers for loan to library users.

During this period users have continued to be presented a choice of free microfiche copies or hard copy at 10¢ per page. Duplicate microfiche are made on-demand with diazo process Bell and Howell microfiche duplicating equipment and hard copy on a Xerox fiche-to-hard-copy Microprinter. Most of the material included in the Microform Service Area collection is also available in standard format in the M.I.T. libraries, subject to standard loan policy.

The charts which follow present the results of the user preference study. The data was collected on questionnaires completed by each user of the Microform Service Area.

Type of Order	Number	Percent
Orders for Microfiche	673	87
Orders for hard copy	98	13
Total	771	100

Fig. III-6 Orders for Microfiche vs. Orders for Hard Copy
1/170-6/30/70

The percentage of users choosing fiche has increased over the time span covered. During the calendar year 1970 this percentage was 82%; for the first six months of 1971 it was 91%.

The reasons given for choosing fiche over hard copy are listed in Fig. III-7.

Reason for Choosing Fiche	Number	Percent
Less expensive	196	37
Convenient size	191	36
Curious about fiche	97	18
Miscellaneous	48	10

Fig. III-7 Users' Reasons for Choosing Fiche over Hard Copy
1/1/70-6/30/71

The percentage of users citing the cost differential as a reason for choosing fiche has declined appreciably during the study for the calendar year 1970. This percentage was 43% but dropped to 31% for the period January through June, 1971. There was a corresponding rise in convenient size as the reason for choosing fiche, from 24% for 1970 to 49% for January through June, 1971.

The reasons users gave for choosing hard copy are given in Fig. III-8.

Reason for Choosing Hard Copy	Number	Percent
No reader available outside library	45	67
Need for frequent referral	14	21
Dislikes fiche	5	7
Miscellaneous	4	5

Fig. III-8 Users' Reasons for Choosing Hard Copy over Fiche
1/1/70-6/30/71

Figure III-9 correlates the fiche/hard copy choice to the hard copy cost of each order. The figures indicate that the percentage of users choosing free fiche remains approximately constant over a range of hard copy costs.

Total Cost of Order at 10¢ per Page	Number Choosing Fiche	Number Choosing Hard Copy
$ .00 - .50	87 (86%)	14 (14%)
.51 - .99	63 (89%)	8 (11%)
1.00 - 2.00	83 (88%)	11 (12%)
2.01 - 3.00	59 (84%)	11 (16%)
3.01 - 5.00	71 (92%)	6 (8%)
5.01 - 10.00	112 (82%)	25 (18%)
10.01 - 20.00	105 (88%)	14 (12%)
20.01+	92 (90%)	10 (10%)

Fig. III-9 Correlation between cost of hard copy and user choice of fiche or hard copy.

The study clearly indicates that microfiche is an acceptable information format when certain conditions are fulfilled. The library's microform reading environment should be as comfortable as conventional study areas; equipped with modern, easy-to-use microform readers; and should offer on-demand copy service. If microfiche are to be loaned or provided for permanent retention, portable microfiche readers should be available for loan. Finally, the cost to the user for duplicate fiche should approximate the actual cost to the library of providing that service. Obviously, this cost will be something more than free, but our experience indicates that it need not be more than 10 - 25¢ per fiche, depending largely on demand.

During the next reporting period the microfiche collection will continue to grow with the addition of 1971 M.I.T. engineering theses, additional society papers, current technical reports, and back issues of high-demand journals.

Use of the Microform Service Area has now reached a level where it will be possible to shift fiche and hard copy costs to test user preference at various cost levels.

E. VISITOR'S PROGRAM

Staff Members

Mr. C. H. Stevens
Miss M. P. Canfield
Mr. J. J. Gardner
Miss R. L. Taggart

In an effort to share our work with the library community and to benefit from professional discussions of our work we began a formal visitor's program during this period. Librarians were invited to attend day-long programs held on two days each in May, June and July. The groups were kept small in an attempt to develop the most open kind of discussion possible.

Thirty-one library administrators from special and academic libraries and library school faculty attended the six programs. Each day's program included a presentation on the Barker Engineering Library's architecture, organization, and collections; a description of the Model Library Program's projects; a brief overview of the Project Intrex experiments; and three periods of examination and use of the Barker library, the Intrex consoles, and the Model Library facilities. Each program was concluded with an open discussion of the project and its future plans.

Attendees were supplied feedback worksheets which were to be completed at their convenience and returned to the project. The worksheet asked for criticisms of the visitor's program, criticisms of the Model Library Program and general comments.

The eighteen attendees who have responded were unanimously appreciative of the opportunity to attend the program with two suggesting expansion of the program to two days.

The response to the Model Library activities was enthusiastic, indicating a desire to have them continued, expanded, and more widely shared. The immediate utility of Pathfinders and the point-of-use instruction programs was obvious to almost all participants. Some representative comments follow:

> The Pathfinders are certainly one of the brighter ideas to come along in some time. I hope we will be able to help with them soon. The microfilm service area was very impressive physically. I remain skeptical about user acceptance in general, but perhaps if M.I.T. can breed a more open minded group of engineers, we all may be able to keep our libraries in a shoe box.
>
> \- Professional Society Librarian, New York
>
> The Pathfinders and the film loops on catalog usage should be continued, for they offer immediate help to librarians. However, it is the Intrex project itself that is the most exciting part of the model Library, and the one offering the greatest promise for radical improvement in librarianship.
>
> \- University Reference Librarian, Boston

> If possible, continue to entertain small groups. Unless visitors already possess background, try to give each one a few minutes actual practice at the consoles - I valued this especially. . . I found your console area suggestive for our building program and the point-of-use continuous tape cassettes and Pathfinders immediately transferable.
>
> - College Librarian, Massachusetts

> Particularly impressive was the fact of the Model Library, ideas in actual operation, even the sophisticated and exotic automated ones. Keep it that way. I believe that all areas of the Model Library Program should be continued. Things such as the feedback notebooks with the library response or dialog are great. . . . . I was very pleased with all of the Model Library ideas, applications, and equipment. The Pathfinders are great and beyond criticism. The AV point-of-use instruction equipment is excellent. The extensive use of signs is most helpful. The Intrex facilities and system are most impressive and obviously easy to use as well as being fascinatingly practical. All of these things and the others not enumerated should help significantly to improve the effectiveness of the library to the user. How I can adapt some of the ideas is now my exercise.
>
> - Special Librarian, Massachusetts

> Pathfinders . . . Obviously this is simple, useful, and inexpensive and should certainly be continued. Point-of-Use Instruction. I think this is an excellent idea, and I hope it will be developed further. The tapes and equipment should be established for a variety of tools and made available to other libraries at a reasonable cost . . . I believe that one of the most important contributions the Model Library Project can make is to provide the leadership for inter-library cooperative activities.
>
> - Special Librarian, Maryland

> All of the current projects should be continued since they are of definite value to all types of libraries. The emphasis on measuring user response to each of the programs is undoubtedly of real importance.
>
> - College Librarian, New Jersey

The suggestions most frequently received were that the program's activities be more widely publicized and that inter-library cooperation be expanded in the areas of Pathfinders and point-of-use instruction programs. These suggestions have led us to begin to formulate means of increasing public awareness of our work and have indicated the desirability of continuing the visitor's program in the fall.

In addition to this formal visitor's program, the Model Library staff held half-day programs for groups of library school students from Simmons College and from Western Ontario University. The experience with these groups reinforced the reactions received from the formal visitor's program. Informal visits by individual librarians and scientists from other countries and states occur with increasing regularity. During the last six months there have been more than 70 of these visitors - more than one every other working day.

IV. PROJECT INTREX STAFF

A. PROJECT OFFICE

Professor Carl F.J. Overhage, Director

Mr. Charles H. Stevens

B. ELECTRONIC SYSTEMS LABORATORY

Professor J. Francis Reintjes
Mr. Alan R. Benefeld
Mr. Larry E. Bergmann
Mr. Joseph Bosco
Mr. D.J. Bottaro
Mrs. Susan Brown
Mr. Dennis W. Buckley
Mr. Peter Campoli
Mr. Yiu T. Chan
Miss Margaret A. Flaherty
Mr. M.S. Fuller
Mr. Robert Goldschmidt
Mr. Daniel J. Griffin
Mr. Charles E. Hurlburt
Miss Margaret A. Jackson
Mr. James E. Kehr
Mr. R. Klein
Mr. Donald R. Knudson
Mr. D.B. Krasnick
Mr. Peter Kugel
Mr. Stephen G. Kuyamjian
Miss Linda A. Langille
Miss Lucy T. Lee
Mr. Richard S. Marcus
Mr. Patrick L. Martin
Miss Mary M. McMillin
Miss Virginia A. Miethe
Mr. Michael K. Molnar
Professor James K. Roberge
Mr. John O. Silvey
Mr. F. Spahn
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Miss Barbara C. Darling
Mrs. Kate Herzog
Miss Carol L. Keator
Mr. James M. Kyed
Miss Helen Magedson
Miss Susan Nutter
Miss Mary Pensyl
Mr. David C. Van Hoy

D. MODEL LIBRARY PROGRAM

Mr. Jeffrey J. Gardner
Miss Marie P. Canfield
Miss Molly Garfin
Mrs. Elizabeth King
Miss Karen Kugell
Miss Katherine C. Todd
Miss Jane Staffier

V. CURRENT PUBLICATIONS

A. REPORTS

Hurlburt, C.E., Molnar, M.K., and Therrien, C.W., "The Intrex Retrieval System Software," ESL-R-4[illegible], September 15, 1971.

Uemura, S., "Intrex Subject/Title Inverted-File Characteristics," ESL-TM-454, September, 1971. (In Press)

Goldschmidt, R.E., "File Design for Computer-Resident Library Catalogs," ESL-R-451, June, 1971. (Also a Ph.D. thesis, June 1971)

B. BOOK CHAPTERS, JOURNAL ARTICLES, AND CONFERENCE PAPERS

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Kugel, P., "Dirty Boole?" Journal of the American Society for Information Science, Vol. 22, No. 4, July, 1971, pp. 293-294.

C. THESES

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Goldschmidt, R.E., "File Design for Computer-Resident Library Catalogs," Ph.D. thesis, Electrical Engineering Department, Massachusetts Institute of Technology, June, 1971. (Also Electronic Systems Laboratory Report ESL-R-451.)

D. MISCELLANEOUS PRESENTATION

Charles H. Stevens

"The Role of Technology in Library Operation, Cooperation, and Architecture," Capital District Library Council, Schenectady, New York, August 17, 1971.

"Point-of-Use Instruction in Libraries," Greater Boston College and University Librarians, Waltham, Mass., June 10, 1971.

"Library Pathfinders," New England College Librarians Conference, Durham, N.H., April 17, 1971.

"A Model Approach to Library Instruction," Catholic Library Association, St. Louis, Missouri, March 27, 1971.

E. INSTRUCTIONAL AIDS

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Bryant, L.S., "User's Guide to Intrex," M.I.T., April, 1971.

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VI. PAST PUBLICATIONS — October, 1969 through 15 March, 1971.

A. REPORTS

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Kusik, R.L., "A File Organization for the Intrex Information Retrieval System on the 360/67 CP/CMS Time-Sharing System." ESL-TM-415, January, 1970.

Lovins, J.B., "Error Evaluation for Stemming Algorithms as Clustering Algorithms." ESL-R-411, December, 1969.

Haring, D.R., "The Augmented-Catalog Console for Project Intrex (Part II)." ESL-TM-410, December, 1969.

Project Intrex Staff, Semiannual Activity Report, 15 March 1971.

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B. BOOK CHAPTERS, JOURNAL ARTICLES, AND CONFERENCE PAPERS

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Reintjes, J.F., "Recent Experiments with the Project Intrex Information Storage and Retrieval System." Gordon Conferences, New London, New Hampshire, 16 July 1970.

Knudson, D.R., and Vezza, A., "Remote Computer Display Terminals." Conference on Computer Handling of Graphical Information sponsored by SPSE, NMA, and SID, Newton, Mass., 9-10 July 1970, Proceedings, pp. 249-268.

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C. THESES

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D. MISCELLANEOUS PRESENTATIONS

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Stevens, C.H., "The Sky is Not the Limit." Presented at Honeywell Corporation Executive Seminar, Concord, Massachusetts, 16 November 1970.

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* * * * *

Earlier publications and presentations are listed in previous issues of the Project Intrex Semiannual Activity Report.